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Genera and Subgenera of the *Lygus* Complex (Hemiptera: Miridae)[1]

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The classification of species of the *Lygus* complex has been somewhat unsatisfactory. Many species were assigned to the genus *Lygus* solely on the basis of superficial characters and many were transferred from one species group to another on the same inadequate basis. In the present paper the characters of the genera and subgenera of the complex are defined.

Study of structures of the internal male and female genitalia revealed characters of considerable taxonomic value. These, taken in conjunction with external taxonomic characters, enable the species of the complex to be classified into 14 genera or subgenera. Among other things, the investigation showed that the economically important "lygus" bugs are not of the genus *Lygus* Hahn, but of the genus *Liocoris* Fieber.

The structures of the internal genitalia that exhibit the best generic, subgeneric, or specific characters are the claspers and the vesica of the male, and the sclerotized rings and the posterior wall and its associated structures of the bursa copulatrix of the female. The female copulatory structures are of the highest taxonomic value.

The nomenclature used here for the various female structures (Fig. 92) and their associated parts is that of Slater (1950) and Davis (1952), with the following modifications: the mesial thickening of the posterior wall of the bursa copulatrix that was referred to by Slater as structure B and by Davis as the sigmoid process is referred to here as the *median process;* the two saclike lobes or invaginations of the inter-ramal sclerites that were referred to by Slater as the E structures are referred to here as the *inter-ramal lobes;* the prominent lobes that arise near the dorsolateral margins of the inter-ramal sclerites that were referred to by Slater as the H structures are referred to here as the *lateral lobes;* and the membranous fold that in some species extends anteriorly from the dorsal margin of the inter-ramal sclerites and that was referred to by Slater as structure C is referred to here as the *dorsal structure* (Figs. 92-94).

The lobes of the vesica may be membranous or sclerotized, or they may be separate or united. Some lobes bear short spines, or the lobes may bear large rodlike sclerites. Generally a primary spiculum is present. A thick, ringlike external gonopore is present, which, according to Carvalho (1952b), is characteristic of the Mirinae. For the nomenclature of the vesica see Figs. 29 and 32.

The genitalia were examined in glycerine after treatment with ten per cent caustic potash.

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If the petition "A proposal to use the plenary powers to fix the type species of the Genus *Lygus* Hahn, 1833", by J. C. M. Carvalho, H. H. Knight, and R. L. Usinger, to the International Commission on Zoological Nomenclature is accepted, the following will be effected:—

Lygus Hahn, 1833, containing the type *Cimex pabulinus* L. and the species of *Neolygus* Kngt., *Apolygus* China, and *Stechus* Dist. will become *Lygocoris* Reut., 1875. *Liocoris* Fieb., 1858, with *Cimex tripustulatus* F. as type and containing the "lygus bugs" of economic importance, will become *Lygus* Hahn, 1883, with *pratensis* (L.) as type.

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Genus *Lygus* Hahn, 1833

Recognized by the generally elongate form of the species, the delicate texture of the cuticula, the fine punctures on the pronotum and hemelytra, and the long, dense pubescence. The genus containus four closely related subgenera. It is cosmopolitan in distribution.

Subgenus *Lygus* Hahn, 1833 (=*Lygocoris* Reuter, 1875)

Figs. 1, 29, 57, 92.

Type of subgenus: *Cimex pabulinus* L., 1761

Distinguished by the pale green colour, the obsolete transverse carina on the middle of the vertex, and by the forms of the genital structures.

Male genitalia: Basal lobe of left clasper well developed, rounded; body of clasper uniform in thickness, terminating in a point; right clasper with apical process sightly curved, the calosity separated by the depression (Fig. 1); vesica with four membranous lobes, three of these sparingly spinose; spiculum thick on basal half, slender on apical half, heavily sclerotized; seminal duct relatively long and slender, bulbous near its apex (Fig. 29).

Female genitalia: Sclerotized rings subtriangular, each strongly tapering to a pointed mesial end (Fig. 57); posterior wall of bursa copulatrix with the inter-ramal lobes kidney-shaped and spinose, lateral lobes large, well developed, broader laterally than mesially, apparently joined mesially; dorsal structure rounded, partially concealed by the lateral lobes; median process relatively small and undeveloped (Fig. 92).

The external appearance and the genital structures of *pabulinus* indicate a close relationship to the subgenera *Apolygus* and *Neolygus*.

Distant (1904a) designated *Lygus pabulinus* (L.) as type of *Lygus* Hahn. The single included species is cosmopolitan in distribution.

Species examined: *pabulinus* (L), Ontario, Alberta, British Columbia, New York, Philippines, and western Europe.

Subgenus *Apolygus* China, 1941

Figs. 2-5, 36, 37, 67-69, 101-103

Type of subgenus: *Lygaeus limbatus* Fall., 1807

Distinguished by the generally green colour with occasional brown markings on the hemelytra, the black spines on the tibia, and the forms of the genital structures.

Male genitalia: Left clasper similar to that of *pabulinus* in general form, but relatively larger, basal lobe not so well developed; right clasper with a prominent apical process, sharply curved (Figs. 2-5); vesica distinctive; spiculum slender or absent; seminal duct greatly expanded (Figs. 36, 37).

Female genitalia: Sclerotized rings not so angular as in *pabulinus*, each widened and rounded laterally, tapering mesially, weakly sclerotized (Figs. 67-69); posterior wall and its associated structures modified but characteristic of the genus (Figs. 101-103).

The claspers of this subgenus vary little in the four species (Figs. 2-5). The vesica of *rhamnicola* is very similar to that of *limbatus* except for the absence of the spiculum; that of *lucorum* is nearly identical with that of *spinolae* (Figs. 36, 37). The sclerotized rings (Figs. 67-69) and the posterior walls of the three species studied are basically similar to one another. The distinctive feature of the posterior wall is the relatively undeveloped inter-ramal lobes which are present as narrow spinose tubes (Figs. 101-103).

The external resemblance and the similarity of the male and female genital structures show the species of *Apolygus* to be closely related to *Lygus pabulinus* and to *Neolygus*. The structures also show subgeneric characters that readily separate this subgenus from the other subgenera of *Lygus*.

The subgenus *Apolygus*, type *limbatus*, was described by China (1941) to include all those species that Reuter (1875) included in the subgenus *Lygus* Hahn. Leston (1952) synonymized *Apolygus* with the older name, *Neolygus* Knight (1917). The present evidence indicates that *Apolygus* is a valid subgenus containing four species: *limbatus* (Fall.), *lucorum* (Mey.), *spinolae* (Mey.), and *rhammicola* Reut. These species are apparently confined to the Palearctic region.

Species examined: *limbatus* (Fall.), Finland and Hungary; *spinolae* (Mey.), Hungary and Europe (no data); *lucorum* (Mey.), Germany and Finland; *rhammicola* Reut., Bohemia.

Subgenus *Neolygus* Knight, 1917

Figs. 6-8, 30-35, 58-66, 93-100

Type of subgenus: *Neolygus communis* Kngt., 1917

Distinguished by the shapes of the male claspers, the relatively long second antennal segment, the pale spines on the tibia, and, in some species, the colour pattern.

Male genitalia: Left clasper more or less right-angled with a protruberance beyond the angle, basal lobe undeveloped; right clasper relatively large, the apical process large and prominent (Figs. 6-8); vesica with four or five membranous lobes and usually with a lobe sclerite; spiculum present, curved or spirally twisted; seminal duct shorter than in *pabulinus*, greatly swollen and bladder-shaped (Figs. 30-35).

Female genitalia: Sclerotized rings somewhat similar to those of *Apolygus* but more heavily sclerotized and more variable in shape (Figs. 58-66); posterior wall with the inter-ramal lobes rounded and spinose, the lateral lobes large, separate or united, and the dorsal structure apparently absent (Figs. 93-100).

The claspers of this subgenus are distinctive. In general, there is little specific variation except in *ostryae* Kngt. and *laureae* Kngt., in which they are modified in shape. The vesicae of the species are very similar to one another except for the presence or absence of the lobe sclerite. The distinctive feature of the posterior wall is the absence of the dorsal structure that is present in *Lygus pabulinus* and *Apolygus*.

The external appearance of species of *Neolygus* is very similar to that of *Lygus pabulinus* and the species of *Apolygus*. The external characters, such as pubescence, puncturation, and the texture of the cuticula, all indicate a close relationship of the subgenera to one another. The structures of the genitalia also show an affinity to *Lygus* but in comparison are more highly specialized.

Neolygus Kngt. (1917) was originally described as a subgenus of *Lygus* to include a large and homogeneous group of closely allied species. Knight (1941) recognized that the biological differences in *Neolygus* were very distinct from those of the *pratensis* (L.) group, and accorded generic rank to his subgenus. Carvalho (1952b) placed *Neolygus* as a subgenus of *Lygus*.

Present knowledge indicates that the *pratensis* group, and not *Neolygus* as was formerly assumed, is the abberant group within the *Lygus* complex.

The majority of the species are Nearctic in distribution, but some are Palearctic.

Species examined: *communis* Kngt., New York., *contaminatus* (Fall.), Carpathes and Europe (no data); *viridis* (Fall.), Europe (no data); *vitticollis* Reut., New York; *inconspicuus* Kngt., Minnesota; *hirticulus* Van D., New York; *canadensis* Kngt., Ontario; *laureae* Kngt., New York; *ostryae* Kngt., Ontario.

Subgenus *Stechus* Distant, 1909

Figs. 9, 40

Type of subgenus: *Stechus libertus* Dist., 1909

Distinguished by the extremely sulcate frons and vertex, the narrow vertex, the large rounded eyes, the long second antennal segment, and the genital structures.

Male genitalia: Left clasper right-angled, basal lobe indistinct, apex pointed with supplemental spur on inner margin; right clasper with apical process large and prominent, right-angled (Fig. 9); vesica with four or five membranous lobes and a lobe sclerite; spiculum present, angled near apex; seminal duct swollen near middle, narrow at base (Fig. 40).

No females were available for examination.

On a basis of external characters *Stechus libertus* Dist. is obviously related most closely to *Lygus*. The structures of the genitalia show a very close relationship to species of *Neolygus* and a study of additional specimens may prove the two groups consubgeneric.

Two male specimens identified by Distant, one of *Stechus libertus* Dist. and the other of *Lygus sordidus* Dist., were examined. These two specimens were found to be conspecific.

Stechus Dist. (1909a) was described to include a single known species. Carvalho (1952a), basing his decision on the external appearance of the species, placed *Stechus* in the genus *Lygus*. The species is confined to the Indo-Malayan region.

Species examined: *libertus* Dist., Ceylon.

Genus *Orthops* Fieber, 1858

Figs. 10-12, 41, 42, 77-79, 110-112

Type of genus: *Cimex kalmii* L., 1758

Distinguished by the short, blunt head, the relatively short and thick second antennal segment, the small size, and the erect pubescence on the dorsum and the genital structures.

Male genitalia: Left clasper similar to that of *pabulinus* in general form but relatively smaller, basal lobe more strongly developed, barb present before the apex; right clasper with a beaked apical process (Figs. 10-12); vesica with four membranous lobes, one slightly enlarged and spinose; spiculum slender; seminal duct swollen at middle (Figs. 41, 42).

Female genitalia: Sclerotized rings elongate-oval (Figs. 77-79); posterior wall distinctive (Figs. 110-112).

The external appearance of the species of *Orthops* and the genital structures are sufficiently different from *Lygus* to justify a generic status. The posterior wall shows certain differences from that of *Lygus* and other genera in the shape of the inter-ramal sclerites, and development of the lateral lobes. The latter are completely fused and extend across the dorsal margin (Figs. 110-112).

The present evidence indicates that the species of *Orthops* as defined by Wagner (1949a) are very heterogeneous and suggest a number of possible subgenera. Four species, *kalmii* (L.), *campestris* (L.), *scutellatus* Uhl., and *foreli* Fieb., were found fundamentally constant in their genital structures, and are therefore considered to comprise the true genus *Orthops*.

A single female each of *viscicola* (Put.), *cervinus* (H.-S.), *atomarius* (Mey.), and *rubricatus* (Fall.) was examined. The structure of the sclerotized rings and the posterior wall indicate that these species are not closely related to *kalmii* or to one another (Figs. 113-116). The genital structures suggest that these species may form a new subgenus. Study of additional species is necessary before the limits of the group can be accurately defined.

The species occur in the Palearctic and Nearctic regions.

Species examined: *kalmii* (L.), Czechoslovakia and Europe (no data); *campestris* (L.), Germany; *foreli* Fieb., Moravia; *scutellatus* Uhl., New York and Idaho; *viscicola* (Put.), Europe (no data); *cervinus* (H.-S.), Europe (no data); *atomarius* (Mey.), France; *rubricatus* (Fall.), Finland.

Genus *Taylorilygus* Leston, 1952

Figs. 13, 14, 43, 44, 70-76, 104-109

Type of genus: *Lygus simonyi* Reut., 1904

Distinguished by the relatively small size and the very distinctive form of the left clasper.

Male genitalia: Left clasper with the basal portion greatly developed and modified into a laminate process, the stem sharply curved and terminating in a hook; right clasper greatly reduced in size, with a short apical process (Figs. 13, 14); vesica with four membranous lobes; spiculum absent; seminal duct expanded in the form of the figure 8 (Figs. 43, 44).

Female genitalia: Sclerotized rings distinctive in shape and in being connected mesially by a slender sclerotized piece formed by coalescence of their margins, anterolateral margin of the dorsal labiate plate with a sclerotized projection (Figs. 70-76); posterior wall with the inter-ramal lobes rounded, situated laterally, not reaching the prominent median process; lateral lobes central in position, membranous and small, fused medially (Figs. 104-109).

The genital structures of species of this genus are very distinctive.

On the basis of internal characters, *Taylorilygus* is not closely related to *Lygus*. The forms of the genital structures are very different and indicate a distinct genus.

Taylorilygus Lest. was described to contain a large and homogenous group of African species of *Lygus* known as the *simonyi* group (=*apicalis* group of Knight, 1917). Taylor (1947) gave an account of the group and showed the uniformity of the species in appearance and structure. The majority of the species are confined to the Ethiopian region, but one is cosmopolitan.

Species examined: *apicalis* (Fieb.), Florida and Mexico; *simonyi* (Reut.), *vosseleri* (Popp.), *nairobiensis* (Popp.), *arboreus* (Tayl.), *virens* (Tayl.), and *compositus* (Tayl.), Uganda, Africa.

Genus *Agnocoris* Reuter, 1875

Figs. 15, 16, 45, 46, 84, 85, 117, 118

Type of genus: *Lygaeus rubicundus* Fall., 1807

Recognized by the very short second antennal segment, the generally small, oval shape of the species, the brown or reddish colour, the dense pubescence, and the genital structures.

Male genitalia: Left clasper sickle-shaped, body relatively thick throughout, narrowing to a point at apex; right clasper with a short, transverse, beaklike apical process (Figs. 15, 16); vesica with four membranous lobes, central lobe enlarged; spiculum straight and relatively short; seminal duct narrow, slightly swollen at middle (Figs. 45, 46).

Female genitalia: Sclerotized rings subovate, each with its posterior margin straight (Figs. 84, 85); posterior wall with the inter-ramal lobes broadly rounded, reaching the prominent median process; dorsal structure membranous, prominent; lateral lobes absent (Figs. 117, 118).

The genital structures and the external appearance indicate that *Agnocoris* is not closely allied to *Lygus*. However, close relationship to *Cyphodema* Fieb. and *Liocoris* Fieb. may exist.

Agnocoris Reut. was originally considered a distinct subgenus of *Cyphodema* Fieb. (1858). However, it was included by subsequent workers in the genus *Lygus* Hahn, where it has been accorded subgeneric status. The forms of the genital structures, the general shape of the species, the short second antennal segment, and the type of pubescence all indicate that *Agnocoris* is a valid genus. The genus contains three species, which are confined to the Nearctic and Palearctic regions.

Species examined: *rubicundus* (Fall.), Germany; *pulverulentus* (Uhl.), New York and Idaho.

Genus *Pinalitus* new genus

Figs. 18, 48, 87, 120

Type of genus: *Deraeocoris approximatus* Stål, 1858

Head oblique, sloping downward at an angle; rostrum nearly reaching the genital segment. Collar typically white. Pronotum and hemelytra very finely punctate, with long, dense, golden pubescence. Form generally narrow and elongate. Colour reddish-brown.

Male genitalia: Left clasper rounded, with the basal lobe well developed, broad; recurved tooth present before the apex; right clasper slender, terminating in a boot-shaped apical process (Fig. 18); vesica with six or seven membranous lobes, one of them uniformly spinose, another slenderly curved and serrate on the inner margin; spiculum bulbous at base, sinuate; seminal duct narrow, slightly constricted at middle (Fig. 48).

Female genitalia: Sclerotized rings ovoid and small; weakly sclerotized, widely separated mesially (Fig. 87); posterior wall with inter-ramal lobes rounded, slightly rugose, without spines along the outer margin; median process small and simple; lateral lobes and dorsal structure absent (Fig. 120).

Pinalitus approximatus resembles Neotropical species of the genus *Alda* Reuter (1909) except for the shorter first antennal segment. The first antennal segment of the species of *Alda* is about twice as long as that of *approximatus*, its length equaling the width of the head across the eyes. The genus *Alda* resembles in general appearance certain members of the genus *Phytocoris* Fall.

Knight (1917), who based his conclusions on the male claspers, noticed the different form of *Lygus approximatus* (Stål) and placed the species in his Group III. Reference to the literature showed that no genus had been described for the species. So far as is known at present, the genus is monobasic. The species is Nearctic in distribution.

Species examined: *approximatus* (Stål), New York.

Genus *Salignus* new genus

Figs. 17, 47, 86, 119

Type of genus: *Lygus distinguendus* Reut., 1875

Head short and blunt; the frons pubescent, with four or five transverse black grooves on each side of the black median depression. Rostrum reaching anterior margin of hind coxa. Tibial spines brown. Pronotum and hemelytra finely punctate, calli pubescent; hemelytra with dense silky pubescence forming pale spots with darker pubescence between. Females dorsoventrally compressed. Colour dark reddish-brown.

Male genitalia: Left clasper angular, the basal lobe broad and strongly developed; recurved tooth present before the apex; right clasper with an oblique apical process (Fig. 17); vesica with four or five membranous lobes, three of them sparingly spinose; spiculum bulbous at the base, curved; seminal duct narrow, swollen near the base (Fig. 47).

Female genitalia: Sclerotized rings oval, small, weakly sclerotized, widely separated mesially (Fig. 86); posterior walls with the inter-ramal sclerites triangular; the inter-ramal lobes not markedly separated mesially; median process and lateral lobes apparently absent; dorsal structure present (Fig. 119).

The structural characters of *distinguendus* (Reut.) are very different from those of any of the other genera studied. Reference to the literature showed that no genus had been described for the species, although from descriptions it appears to resemble *Chrysodasia strigofrons* Reut. (1892), from Venezuela. However the pubescent frons and calli, the silvery pubescence, the spines on the tibia, and the mottled hemelytra readily separate *distinguendus* from *strigofrons*.

At present the genus contains *distinguendus* (Reut.) and a variety, *tahoensis* (Kngt.). The species are Nearctic in distribution.

Species examined: *distinguendus* (Reut.), Alaska.

Genus *Proba* Distant, 1884 (=*Paralygus* Reuter, 1905)

Figs. 19, 49, 88, 121

Type of genus: *Proba gracilis* Dist., 1884

Distinguished by the very shiny appearance, the finely punctate and glabrous pronotum and hemelytra, and the forms of the genital structures.

Male genitalia: Left clasper relatively slender, basal lobe small; right clasper cyindrical, the apex with a short, slender process (Fig. 19); vesica with five or six membranous lobes; spiculum absent; seminal duct slender and tubelike (Fig. 49).

Female genitalia: Sclerotized rings oval and small, very widely separated mesially (Fig. 88); posterior wall with inter-ramal lobes narrow; the median process well developed, partially concealed by a biramous dorsal structure; lateral lobes absent (Fig. 121).

The genus does not appear to be closely related to any of the species of *Lygus* studied. The members of *Proba* show superficial resemblance to certain species of the genus *Horcias* Distant (1884), but the latter can be easily distinguished by the complete absence of the transverse carina between the eyes, and the genital structures.

The majority of the Neotropical species placed in *Lygus* by early workers are not species of *Lygus*, but, as was shown by Carvalho (1952a), belong to the genus *Proba* Dist. A study is needed of the widely distributed species to determine the generic limits of the group.

The genus contains a moderately large number of species found in the Neotropical and Nearctic regions.

Species examined: *vittiscutis* (Stål), Brazil.

Genus *Sabactus* Distant, 1910

Figs. 130, 136

Type of genus: *Sabactus institutus* Dist., 1910

Recognized by the small size, the triangular colour pattern on each hemelytron, and the relatively long head with a fine row of punctures above the antennal fossa. Pronotum and hemelytra lightly punctate, with short, golden pubescence. Rostrum extending beyond hind coxa.

No males were available for examination.

Female genitalia: Sclerotized rings very large for the size of species, rectangular, mesial margins almost in contact with each other (Fig. 136); posterior wall with inter-ramal lobes relatively narrow and widely separated, each divided at apex; median process apparently absent; lateral lobes and dorsal structure present (Fig. 130).

The sclerotized rings and the posterior wall show remarkable structural characteristics and indicate that the species is not related to *Lygus*.

The female specimen studied was labelled *Lygus devinctus* Dist. Reference to the literature showed that the species is identical with *Sabactus institutus* Dist. Dr. Carvalho (in litt.) has corroborated the synonomy. The species is confined to the Indo-Malayan region.

Species examined: *institutus* Dist., Nepal.

Genus *Dagbertus* Distant, 1904

Figs. 20-24, 50-54, 89-91, 122-124

Type of genus: *Capsus darwini* Butl., 1877

Head short and blunt, the vertex and eyes crescent-shaped, the eyes large, partially covering the anterior angles of the pronotum, the vertex forming a ledge over the collar. Third antennal segment shorter than head length. Rostrum reaching posterior margin of hind coxa, except in *quadrinotatus* (Walk.), in which it reaches the sixth abdominal segment. Pronotum and hemelytra finely punctate, with long, dense, silvery pubescence. General colour green, occasionally marked with reddish.

Male genitalia: Left clasper with basal lobe weakly developed, bifurcate near apex; right clasper small, apical process greatly reduced and inconspicuous (Figs. 20-24); vesica apparently three-lobed; spiculum present, variously shaped; seminal duct swollen at middle (Figs. 50-54).

Female genitalia: Sclerotized rings oval, widely separated mesially, and connected by a sclerotized band (Figs. 89-91); posterior wall with the median process concealed by a bulbous dorsal structure; lateral lobes absent (Figs. 122-124).

On the basis of external characters this group of species is very close to *Taylorilygus* Lest. However, species of *Dagbertus* are separated from those of *Taylorilygus* by the genital structures, the reddish colour markings on the head and hemelytra, and the shorter third antennal segment.

The *fasciatus* Group IV of Knight (1917), containing *Lygus fasciatus* Reut. and *L. olivaceus* Reut. from the tropical regions of the United States, belongs to the genus *Dagbertus* Dist.

This is a small genus, the members of which are Neotropical and Nearctic in distribution.

Species examined: *quadrinotatus* (Walk.), Galapagos Islands; *fasciatus* (Reut.), Florida; *olivaceus* (Reut.), Florida and Jamaica; *bonariensis* (Stål), Brazil; *phaleratus* (Berg), Paraguay.

Genus *Liocoris* Fieber, 1858 (=*Exolygus* Wagner, 1949)

Figs. 25-27, 38, 55, 56, 125-128, 131, 132, 134, 135

Type of genus: *Cimex tripustulatus* F., 1781

Recognized by the relatively thick body integument, the coarsely punctate pronotum and hemelytra, and the distinctive genital structures.

Male genitalia: Left clasper evenly curved, C-shaped, basal lobe strongly developed, the crown serrate, apex truncate and tooth-shaped; right clasper with the apical process slender, straight or curved (Figs. 25-27); vesica with five lobes, one lobe somewhat triangular and densely spinose on apical half; spiculum slender, slightly curved; seminal duct swollen at apical half (Figs. 38, 55, 56).

Female genitalia: Sclerotized rings variously shaped, widely separated, the rings relatively thick, with adjacent sclerotization on the dorsal labiate plate large and prominent (Figs. 131, 132, 134, 135); posterior wall usually with the inter-ramal lobes spinose; median process prominent; dorsal structure membranous, the central dome fitting over the median process; lateral lobes absent (Figs. 125-127).

The affinity of *Liocoris* is clearly with *Exolygus* Wagn., as shown by the general appearance of the species and the closely similar forms of the genital structures. The genital structures of these groups are very similar in the basic pattern and show an extremely close relationship. These characters also indicate that *Liocoris* is not even remotely related to *Lygus* Hahn.

Exolygus Wagn. (1949a) was originally described as a subgenus of *Lygus* Hahn to contain the *pratensis* (L.) group. The voluminous literature in North America dealing with the "lygus" pests of economic importance unquestionably pertains to species of the genus *Liocoris* Fieb.

The genus contains approximately 57 species, a few of which are cosmopolitan in distribution, the greater number of species being found in the Nearctic region.

Species examined: *tripustulatus* (F.), France; *pratensis* (L.), Germany and Prussia; *nubilatus* (Kngt.), Idaho; *ultranubilus* (Kngt.), New Mexico; *epelys* (Huss.), Michigan.

Genus *Cyphodema* Fieber, 1858

Figs. 28, 39, 129, 133

Type of genus: *Phytocoris instabilis* Lucas, 1849

Head relatively elongate, the eyes small. Pronotum and hemelytra deeply punctate, bearing dense, golden pubescence. Scutellum black except for the pale median area. Rostrum reaching the third abdominal segment.

Male genitalia: Left clasper similar to that of *Liocoris* but larger, barbs of the basal lobe extending partially up the body; right clasper with a thick, curved apical process (Fig. 28); vesica with five lobes; spiculum sinuate; seminal duct expanded in the form of the figure 8 (Fig. 39).

Female genitalia: Sclerotized rings triangular, thick-walled (Fig. 133); posterior wall with the inter-ramal lobes short, median margins joined at the prominent median process; dorsal structure broadly rounded, disklike in shape; lateral lobes absent (Fig. 129).

Cyphodema is rather closely related to *Liocoris* in external appearance and male genitalia. The posterior wall and its structures are considerably different and indicate that two genera are distinct.

This genus consists of five species, which are Palearctic in distribution.

Species examined: *instabilis* (Lucas), Europe (no data).

Key to Genera and Subgenera of the *Lygus* Complex

1. Species glabrous, very shiny ..... *Proba*
   Species pubescent, hair sometimes very short 2
2. Second antennal segment shorter than head width across the eye ..... *Agnocoris*
   Second antennal segment longer than head width across the eye 3
3. Frons with a black median groove and four or five transverse grooves on each side; hemelytra brown, with patches of silky pubescence *Salignus* n. gen.
   Frons without median groove; hemelytra not as above 4
4. Scutellum with dense, erect pubescence, posteriorly declivous ..... *Orthops*
   Scutellum with depressed pubescence 5
5. Pronotum and hemelytra deeply and coarsely punctate; pubescence generally short and closely appressed 6
   Pronotum and hemelytra finely and shallowly punctate; pubescence generally long and dense 7
6. Length of cuneus shorter than head length; hind tibia without "knee-spots" near base; scutellum black except for the pale median area ..... *Cyphodema*
   Length of cuneus longer than head length; hind tibia with "knee-spots" near base; scutellum with dark median or lateral dashes ..... *Liocoris*
7. Frons with four or five punctures above the antennal fossa; length of head at least 1.7 times the eye length (females only) ..... *Sabactus*
   Frons without punctures above the antennal fossa; length of head less than 1.6 times the eye length 8
8. Rostrum reaching to fifth or sixth abdominal segment; head with a distinct transverse carina; reddish-brown species ..... *Pinalitus* n. gen.
   Rostrum usually shorter; if reaching to fifth or sixth abdominal segment, then head without a transverse carina 9
9. Length of first antennal segment greater than eye length; generally larger and broader species 10
   Length of first antennal segment equal to or less than eye length; generally smaller and narrower species 12
10. Transverse carina of head obsolete at middle, evident only near the eyes; claspers as in Fig. 1 ..... *Lygus* (*Lygus*)
    Transverse carina of head complete 11
11. Left clasper with a protruberance at middle near base (Fig. 8); tibial spines usually pale ..... *Lygus* (*Neolygus*)
    Left clasper without a protruberance at middle; tibial spines black ..... *Lybus* (*Apolygus*)
12. Length of first antennal segment at least twice the width of vertex; claspers as in Fig. 14 (males only) ..... *Lygus* (*Stechus*)
    Length of first antennal segment less than twice the width of vertex 13
13. Basal lobe of left clasper greatly developed and bearing a laminate process; apex not bifurcate (Fig. 9); third antennal segment longer than head length ..... *Taylorilygus*
    Basal lobe of left clasper not bearing a laminate process; apex bifurcate (Fig. 20); third antennal segment shorter than head length ..... *Dagbertus*

Summary

A number of taxonomic changes are proposed in the *Lygus* complex on a basis of external and genitalic characters. *Agnocoris* Reuter, *Orthops* Fieber, and *Taylorilygus* Leston, formerly considered as subgenera of *Lygus* Hahn, are elevated to generic rank. *Neolygus* Knight is reinstated as a valid subgenus of *Lygus* Hahn. *Exolygus* Wagner, 1949, containing the economically important "lygus" bugs and formerly considered a subgenus of *Lygus* Hahn, is treated as a synonym of *Liocoris* Fieber, 1858. Two new genera, *Pinalitus* and *Salignus*, are described for *Lygus approximatus* Stål and *Lygus distinguendus* Reuter, respectively. The *fasciatus* Group IV of Knight belongs to the genus *Dagbertus* Distant.

EXPLANATION OF FIGURES

The genital claspers are designated as follows: A, left clasper, dorsal aspect; A_1, left clasper, apical portion; A_2, left clasper, laminate process; B, right clasper, ventral aspect; B_1 right clasper, lateral aspect.

The vesicae are drawn from the ventral aspect (opposite the gonopore).

The sclerotized rings are drawn from the dorsal aspect.

The posterior walls are drawn from the anterior aspect.

Figs. 1 to 8. Genital claspers of: 1, *Lygus* (*Lygus*) *pabulinus* (L.); 2, *L.* (*Apolygus*) *lucorum* (Mey.); 3, L. (*A.*) *spinolae* (Mey.); 4, L. (*A.*) *rhammicola* Reut.; 5, L. (*A.*) *limbatus* (Fall.); 6, *L.* (*Neolygus*) *viridis* (Fall.); 7, *L.* (*N.*) *contaminatus* (Fall.); 8, *L.* (*N.*) *communis* Kngt.

Figs. 9 to 17. Genital claspers of: 9, *Lygus* (*Stechus*) *libertus* Dist.; 10, *Orthops kalmii* (L.); 11, *Orthops campestris* (L.); 12, *Orthops scutellatus* Uhl.; 13, *Taylorilygus simonyi* (Reut.); 14, *T. apicalis* (Fieb.); 15, *Agnocoris rubicundus* (Fall.); 16, *A. pulverulentus* (Uhl.); 17, *Salignus distinguendus* (Reut.).

Figs. 18 to 28. Genital claspers of: 18, *Pinalitus approximatus* (Stål); 19, *Proba vittiscutis* (Stål); 20, *Dagbertus quadrinotatus* (Walk.); 21, *D. fasciatus* (Reut.); 22, *D. olivaceus* (Reut.); 23, *D. phaleratus* (Berg); 24, *D. bonariensis* (Stål); 25, *Liocoris tripustulatus* (F.); 26, *L. pratensis* (L.); 27, *L. nubilatus* (Kngt.); 28, *Cyphodema instabilis* (Lucas).

Figs. 29 to 39. Vesicae of: 29, *Lygus* (*Lygus*) *pabulinus* (L.) 30, *L.* (*Neolygus*) *contaminatus* (Fall.); 31, *L.* (*N.*) *viridis* (Fall.); 32, *L.* (*N.*) *communis* Kngt.; 33, *L.* (*N.*) *inconspicuus* Kngt.; 34, *L.* (*N.*) *ostryae* Kngt.; 35, *L.* (*N.*) *hirticulus* Van D.; 36, *L.* (*Apolygus*) *limbatus* (Fall.); 37, L. (*A.*) *spinolae* (Mey.); 38, *Liocoris pratensis* (L.); 39, *Cyphodema instabilis* (Lucas).

Figs. 40 to 56. Vesicae of: 40, *Lygus* (*Stechus*) *libertus* Dist. 41, *Orthops kalmii* (L.); 42, *O. scutellatus* Uhl.; 43, *Taylorilygus simonyi* (Reut.); 44, *T. apicalis* (Fieb.); 45, *Agnocoris rubicundus* (Fall.); 46, *A. pulverulentus* (Uhl.); 47, *Salignus distinguendus* (Reut.); 48, *Pinalitus approximatus* (Stål); 49, *Proba vittiscutis* (Stål); 50, *Dagbertus quadrinotatus* (Walk.); 51, *D. fasciatus* (Reut.); 52, *D. olivaceus* (Reut.); 53, *D. phaleratus* (Berg); 54, *D. bonariensis* (Stål); 55, *Liocoris tripustulatus* (F.); 56, *L. nubilatus* (Kngt.).

Figs. 57 to 69. Sclerotized rings of females of: 57, *Lygus* (*Lygus*) *pabulinus* (L.); 58, *L.* (*Neolygus*) *contaminatus* (Fall.); 59, *L.* (*N.*) *viridis* (Fall.); 60, *L.* (*N.*) *communis* Kngt.; 61, L. (N.) *inconspicuus* Kngt.; 62, L. (*N.*) *hirticulus* Van D.; 63, L. (*N.*) *ostryae* Kngt.; 64, *L.* (*N.*); *laureae* Kngt.; 65, *L.* (*N.*); *vitticollis* Reut.; 66, *L.* (*N.*) *canadensis* Kngt.; 67, *L.* (*Apolygus*) *limbatus* (Fall.); 68, *L.* (*A.*) *spinolae* (Mey.); 69, *L.* (*A.*) *lucorum* (Mey.).

Figs. 70 to 77. Sclerotized rings of females of: 70, *Taylorilygus simonyi* (Reut.); 71, *T. apicalis* (Fieb.); 72, *T. nairobiensis* (Popp.); 73, *T. virens* (Tayl.); 74, *T. vosseleri* (Popp.); 75, *T. arboreus* (Tayl.); 76, *T. compositus* (Tayl.); 77, *Orthops kalmii* (L.).

Figs. 78 to 91. Sclerotized rings of females of: 78, *Orthops campestris* (L.); 79, *O. scutellatus* Uhl.; 80, *O. viscicola* (Put.); 81, *O. cervinus* (H.S.); 82, *O. atomarius* (Mey.); 83, *O. rubricatus* (Fall.); 84, *Agnocoris rubicundus* (Fall.); 85, *A. pulverulentus* (Uhl.); 86, *Salignus distinguendus* (Reut.); 87, *Pinalitus approximatus* (Stål); 88, *Proba vittiscutis* (Stål); 89, *Dagbertus quadrinotatus* (Walk.); 90, *D. fasciatus* (Reut.); 91, *D. alivaceus* (Reut.).

Figs. 92 to 103. Posterior walls of the bursae of: 92, *Lygus* (*Lygus*) *pabulinus* (L.) 93, L. (*Neolygus*) *communis* Kngt.; 94, L. (*N.*); *viridis* (Fall.); 95, L. (*N.*) *contaminatus* (Fall.); 96, L. (*N.*) *inconspicuus* Kngt.; 97, L. (*N.*) *hirticulus* Van D.; 98, L. (*N.*) *laureae* Kngt.; 99, *L.* (*N.*) *ostryae* Kngt.; 100, *L.* (*N.*) *vitticolis* Reut.; 101, *L.* (*Apolygus*) *limbatus* (Fall.); 102, *L.* (*A.*) *spinolae* (Mey.); 103, *L.* (*A.*) *lucorum* (Mey.).

Figs. 104 to 116. Posterior walls of the bursae of: 104, *Taylorilygus simonyi* (Reut.); 105, *T. apicalis* (Fieb.); 106, *T. nairobiensis* (Popp.); 107, *T. virens* (Tayl.); 108, *T. vosseleri* (Popp.); 109, *T. arboreus* (Tayl.); 110, *Orthops kalmii* (L.); 111, *O. campestris* (L.); 112, *O. scutellatus* Uhl.; 113, *O. viscicola* (Put.); 114, *O. cervinus* (H.S.); 115, *O. atomarius* (Mey.); 116, *O. rubricatus* (Fall.).

Figs. 117 to 128. Posterior walls of the bursae of: 117, *Agnocoris rubicundus* (Fall.); 118, *A. pulverulentus* (Uhl.); 119, *Salignus distinguendus* (Reut.); 120, *Pinalitus approximatus* (Stål); 121, *Proba vittiscutis* (Stål); 122, *Dagbertus quadrinotatus* (Walk.); 123, *D. fasciatus* (Reut.); 124, *D. olivaceus* (Reut.); 125, *Liocoris tripustulatus* (F.); 126, *L. pratensis* (L.); 127, *L. nubilatus* (Kngt.); 128, *L. ultranubilus* (Kngt.).

Figs. 129 to 130. Posterior walls of the bursae of: 129, *Cyphodema instabilis* (Lucas); 130, *Sabactus institutus* Dist.

Figs. 131 to 136. Sclerotized rings of females of: 131, *Liocoris nubilatus* (Kngt.); 132, *L. ultranubilus* (Kngt.); 133, *Cyphodema instabilis* (Lucas); 134, *Liocoris pratensis* (L); DlbP, dorsal labiate plate.; 135, *Liocoris tripustulatus* (F.); 136, *Sabactus institutus* Dist.

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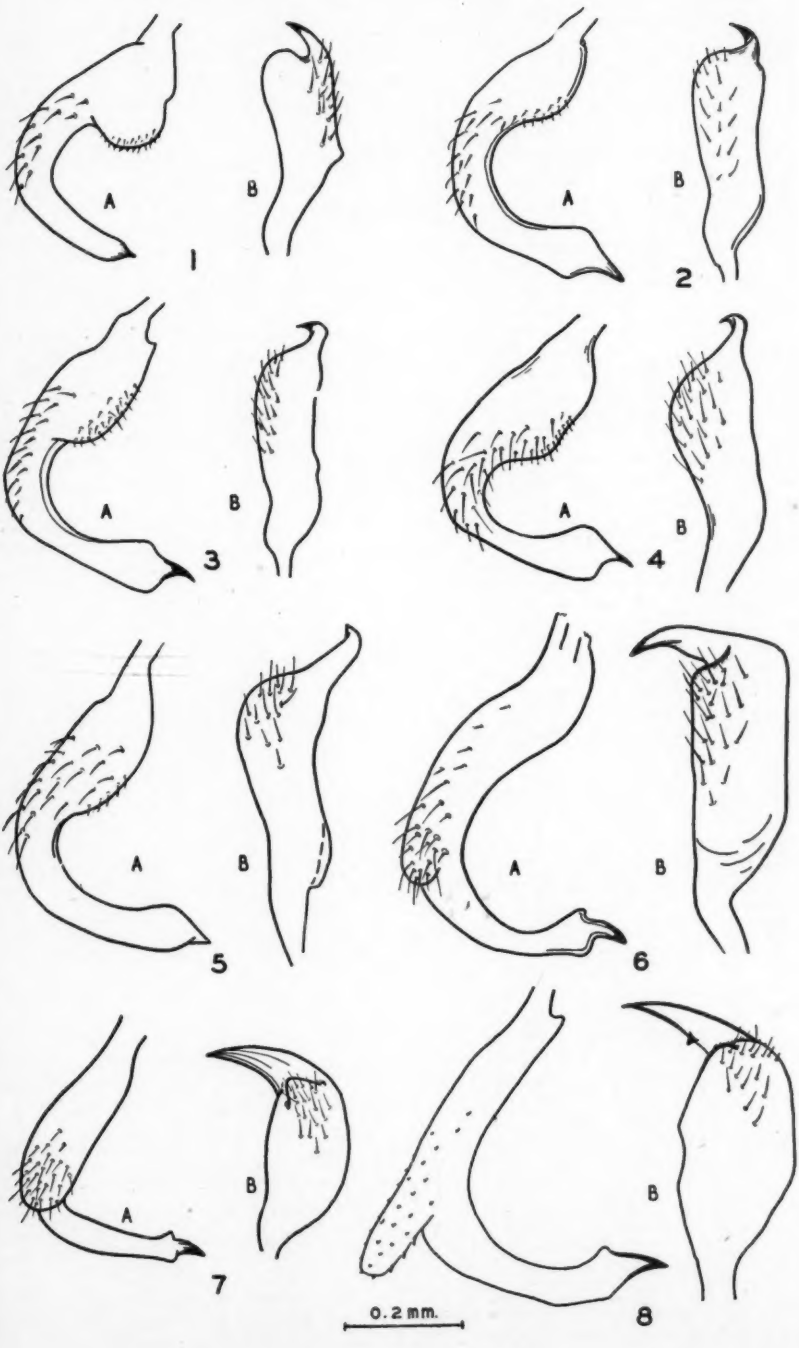
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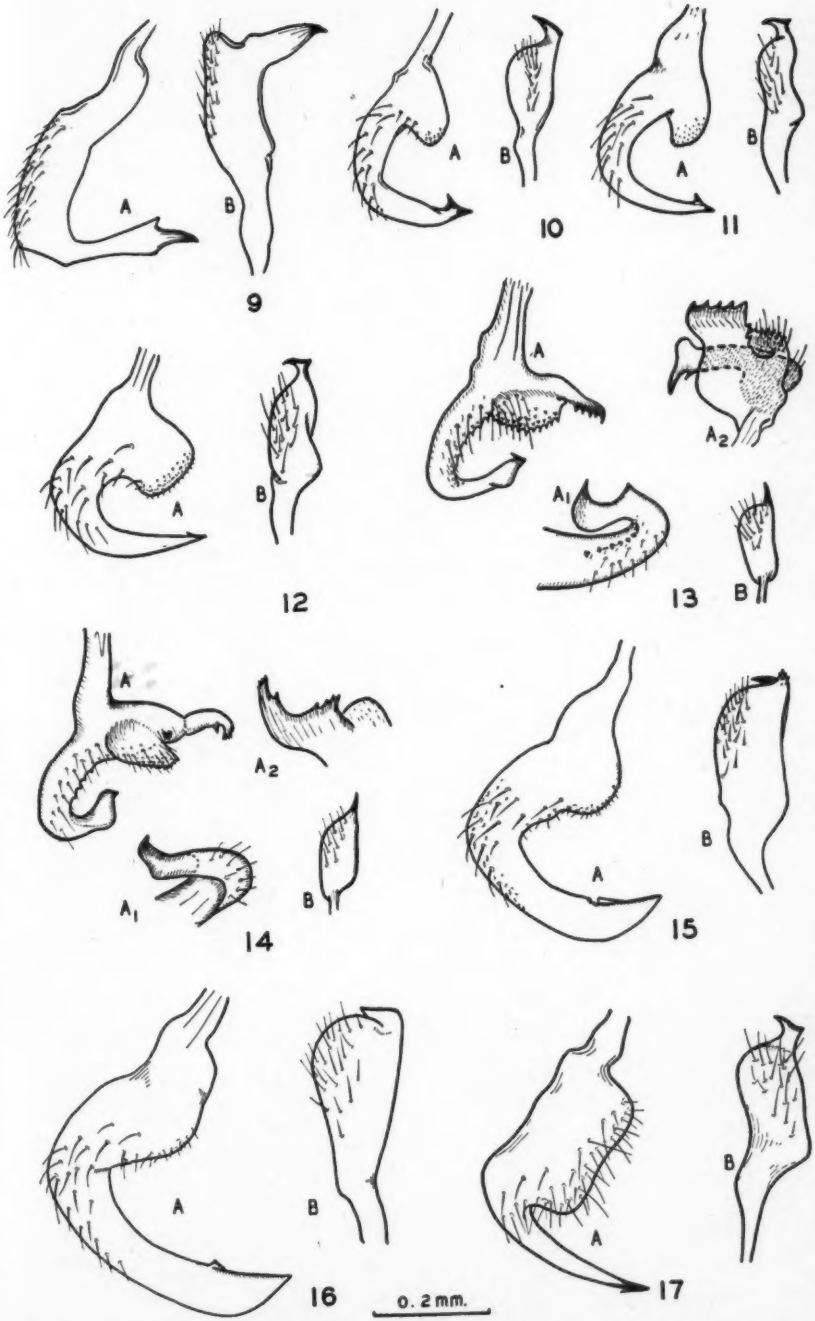
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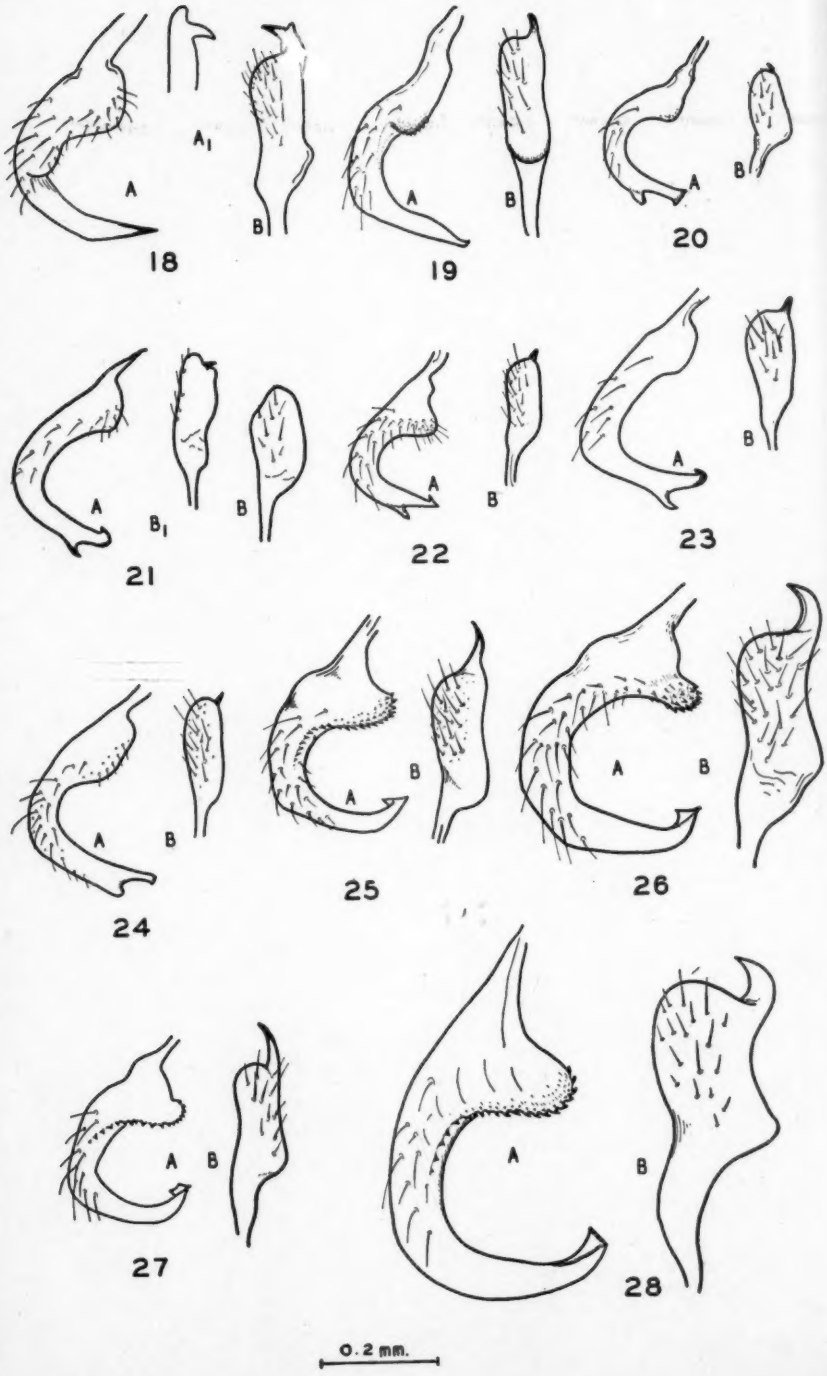
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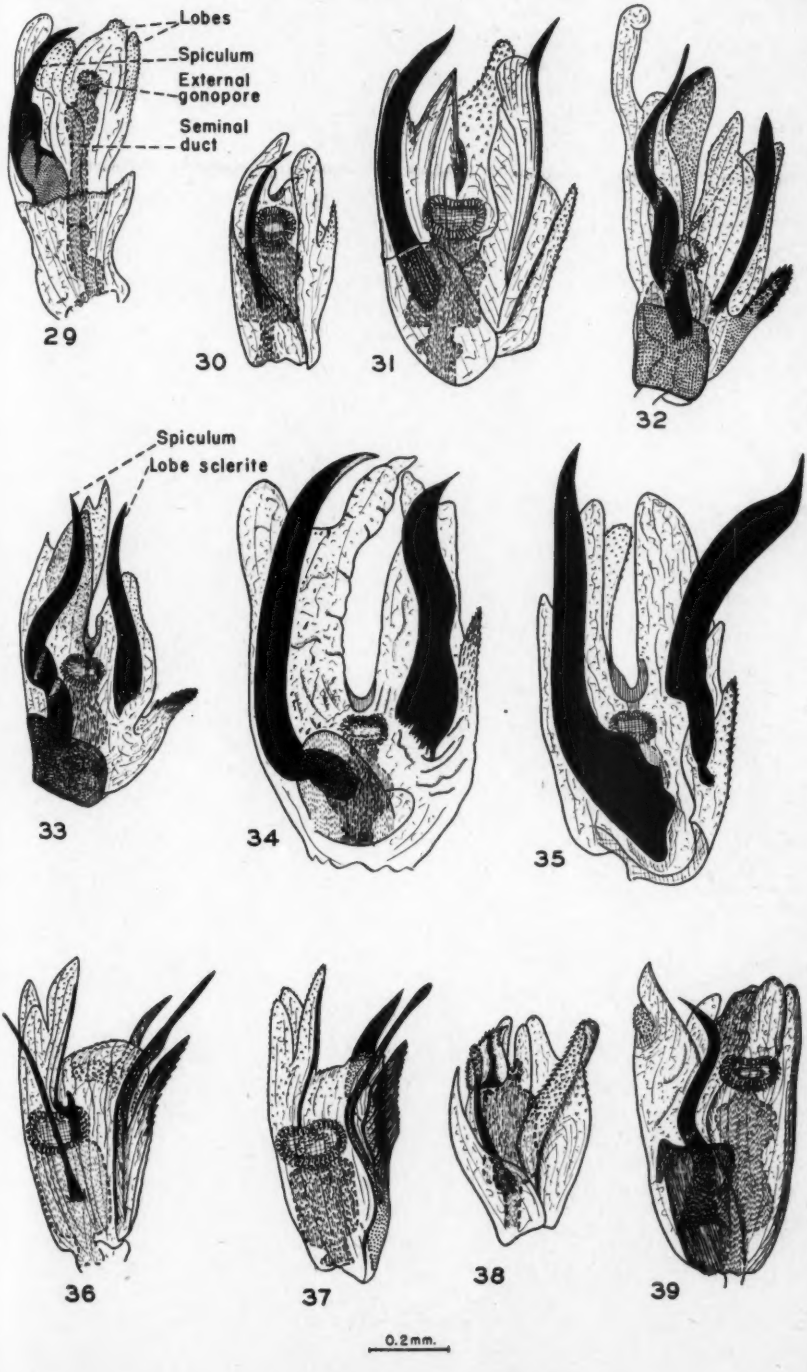
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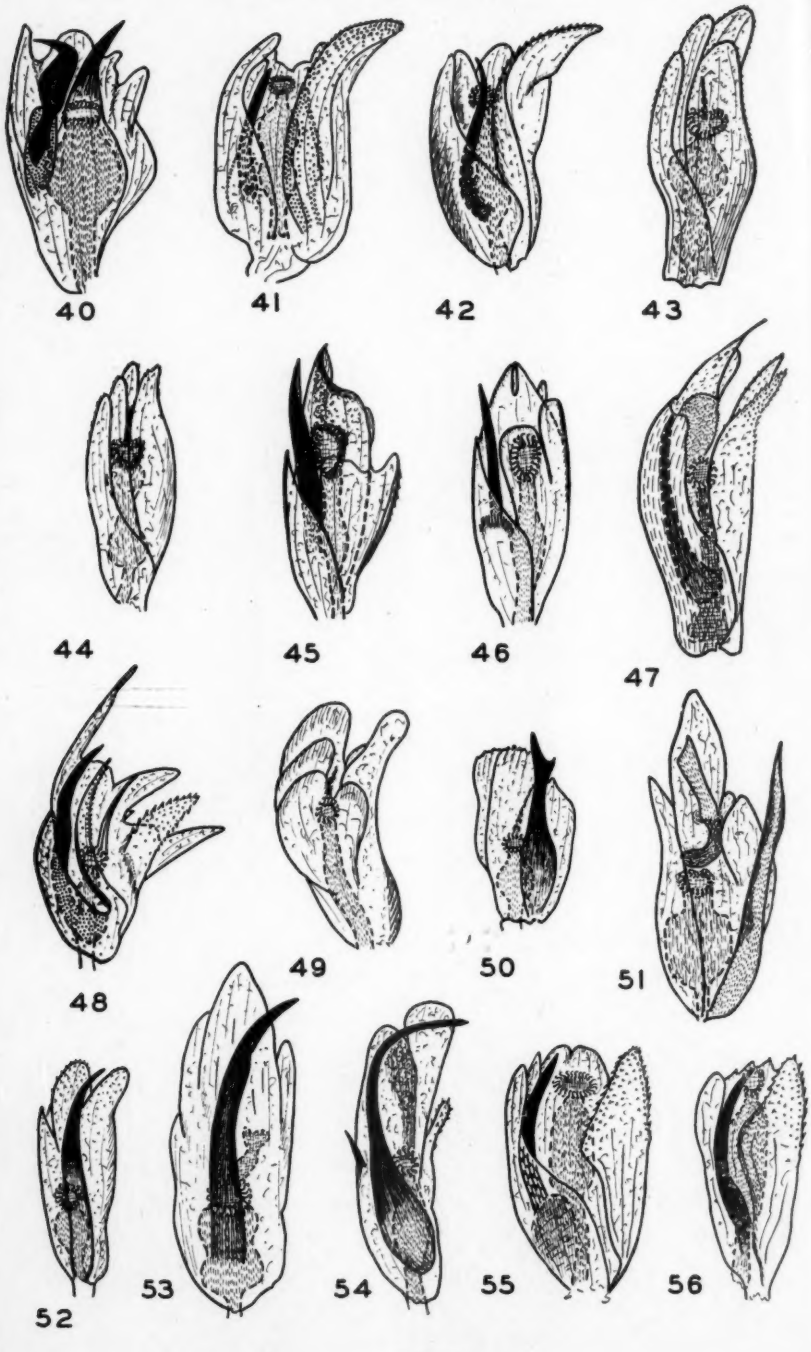
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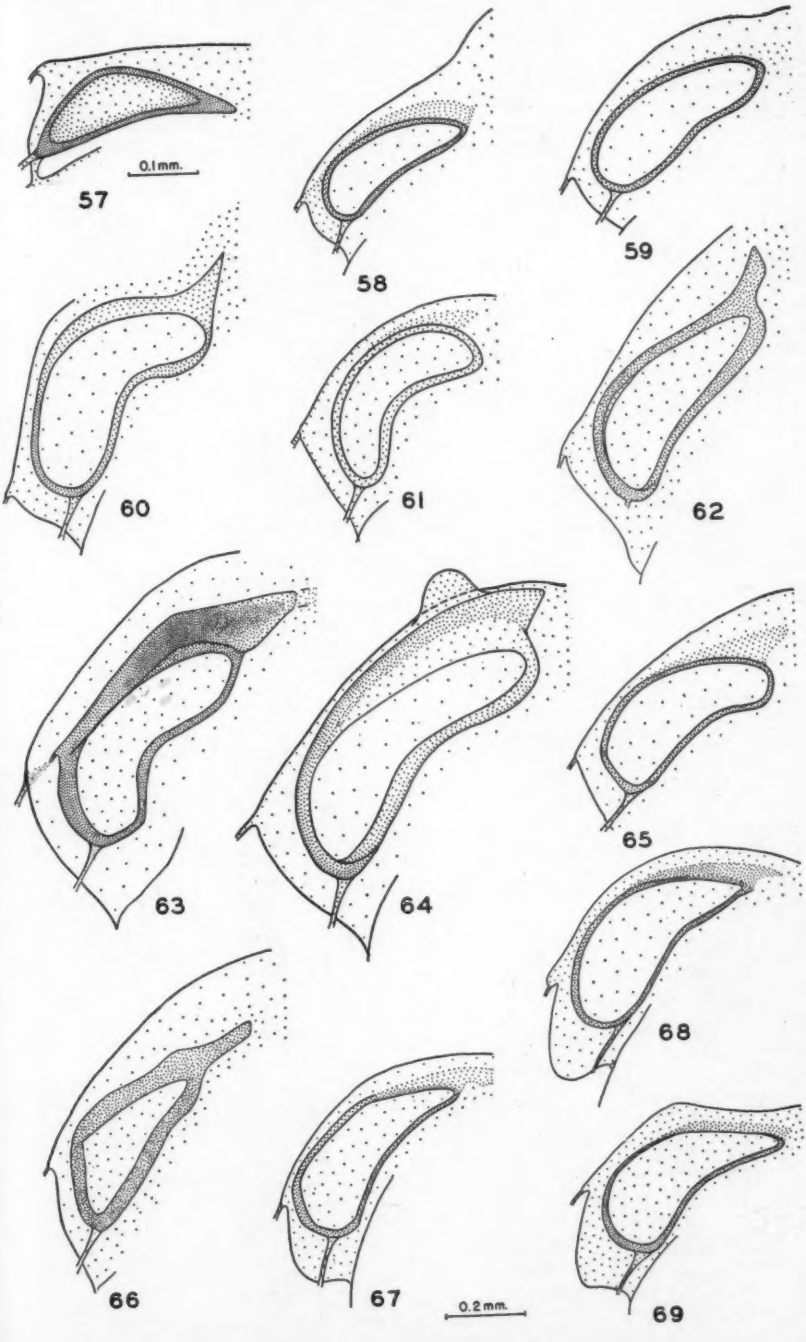
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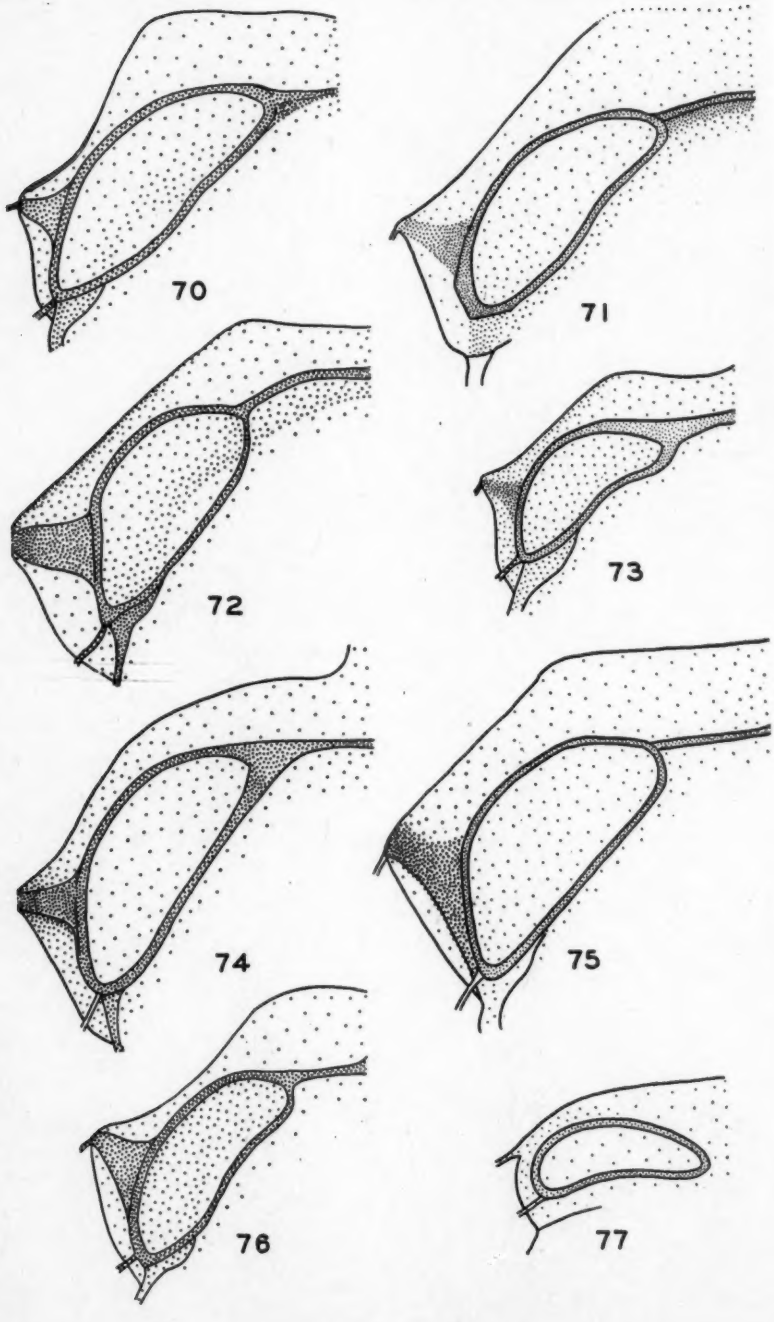
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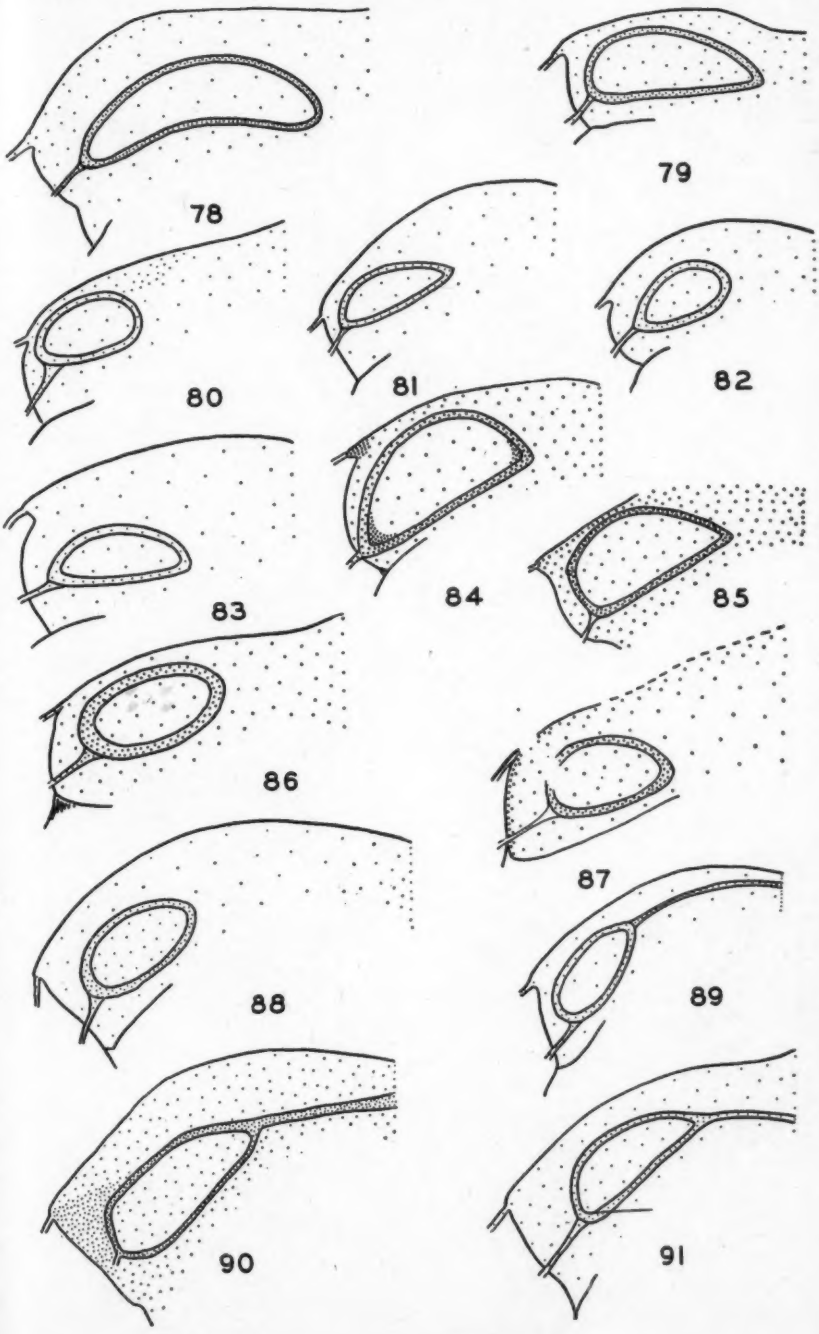
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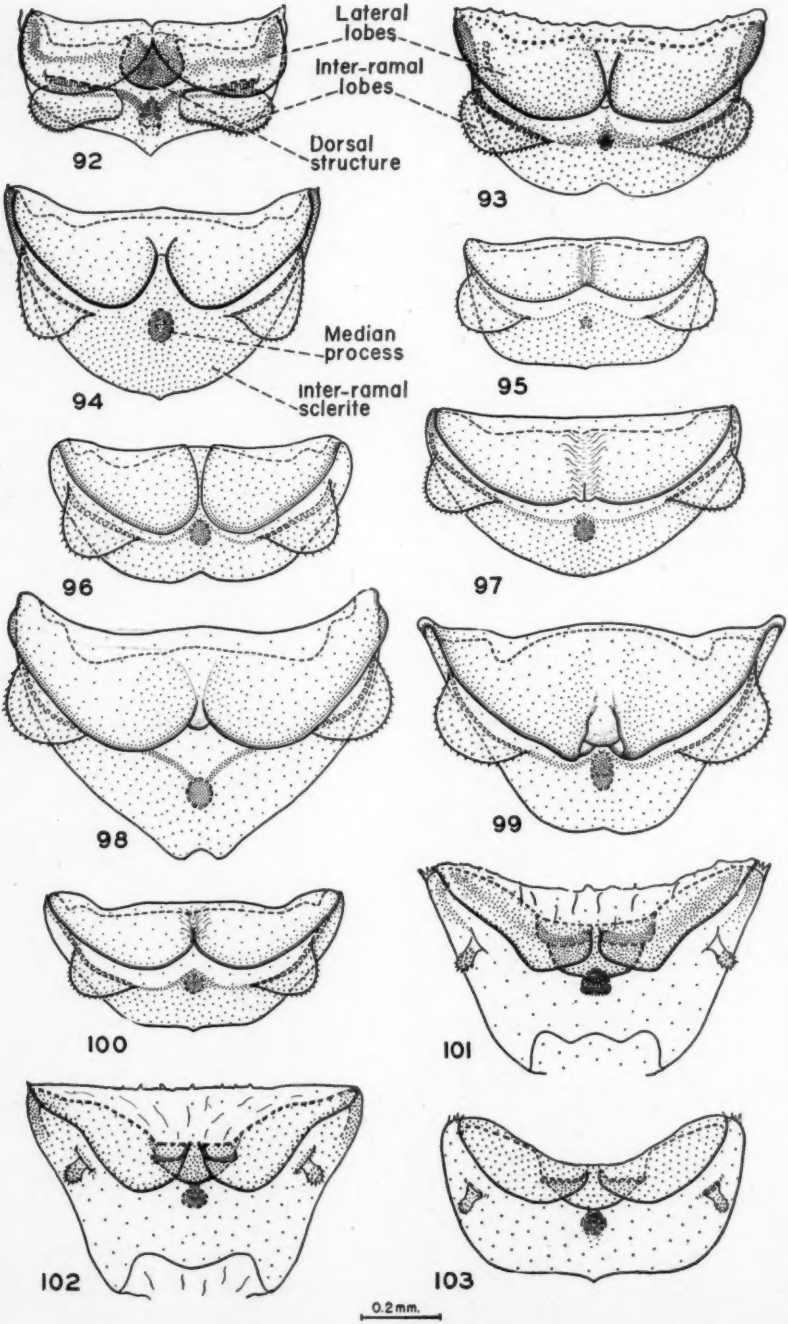
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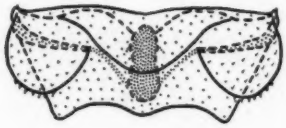

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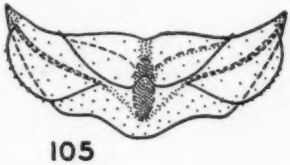

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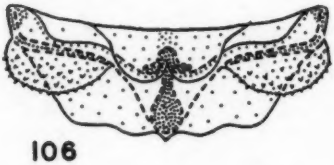

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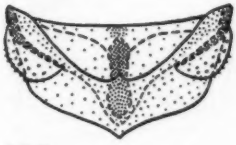

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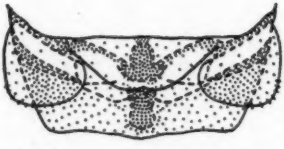

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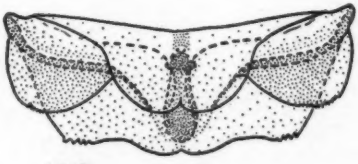

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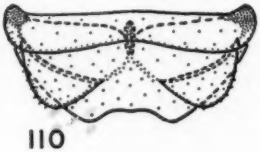

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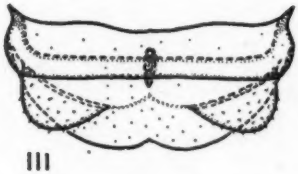

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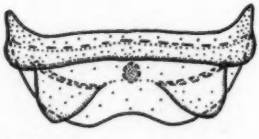

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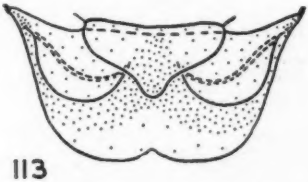

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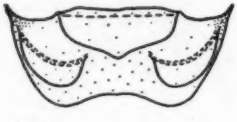

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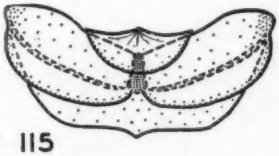

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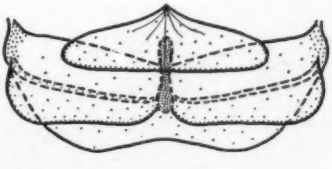

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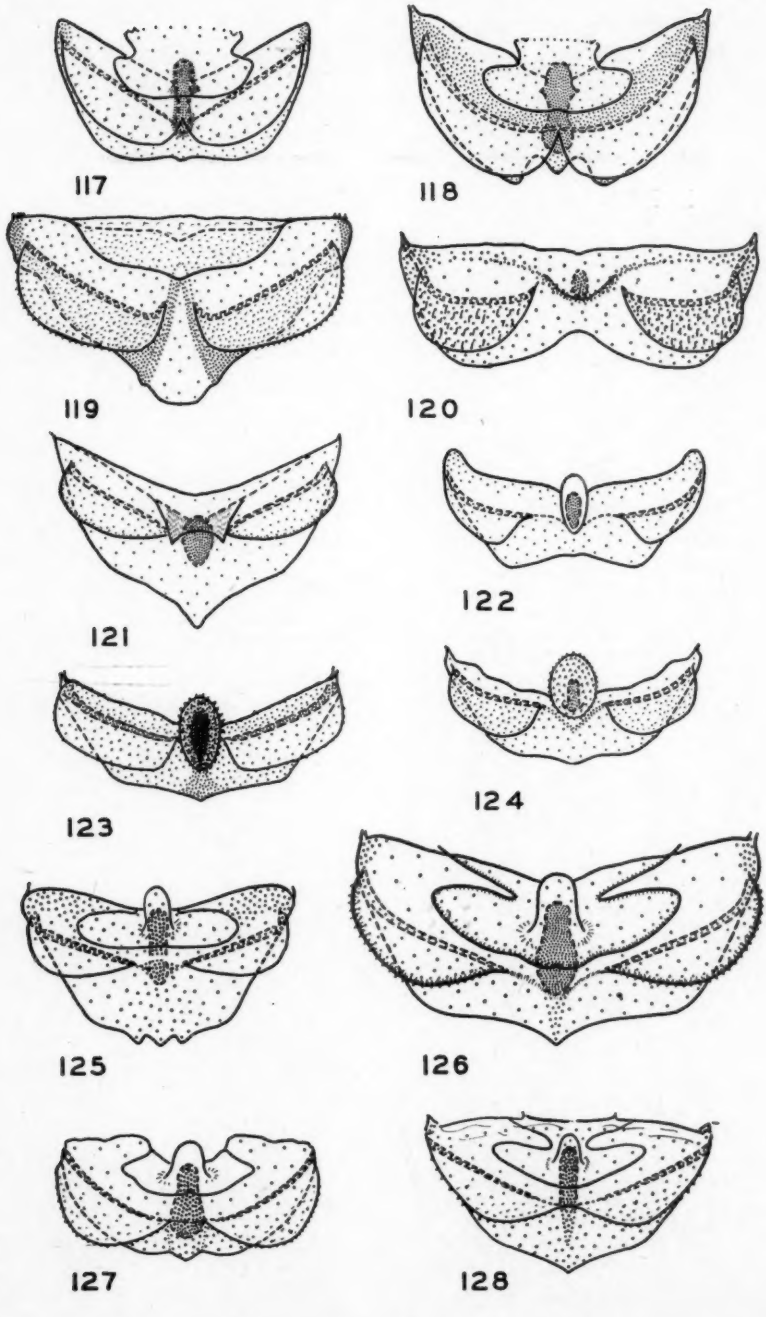
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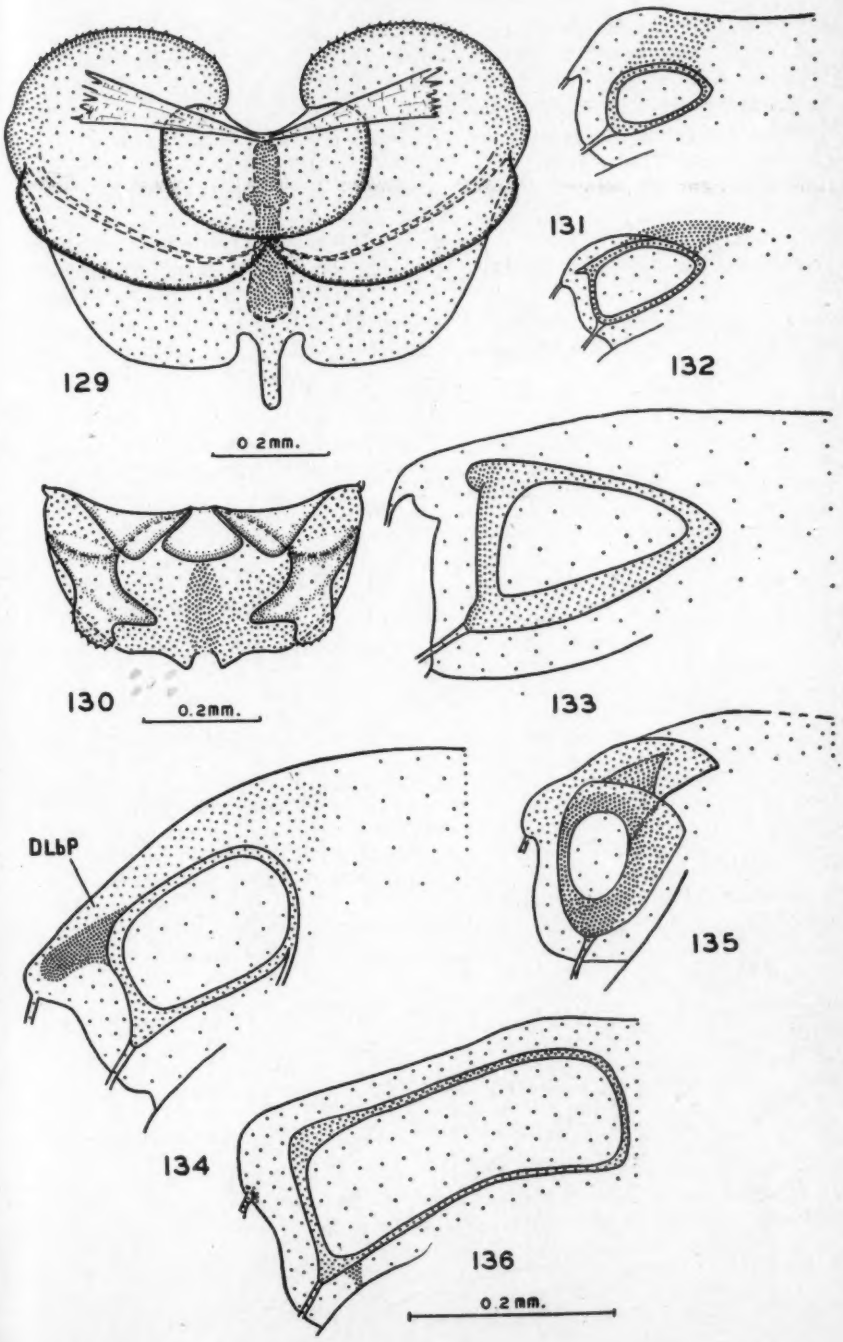
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Acknowledgments

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Effect of Moisture on the Selection of Cocooning Sites by the Larch Sawfly, *Pristiphora erichsonii* (Hartig)[1]

By W. G. H. Ives[2]

Introduction

Mature larch sawfly drop to the ground and spin cocoons in the moss or duff. The ground surface of tamarack bogs is usually uneven, and the moss is variable in moisture content. During hot dry weather the moss on the tops of hummocks in dry sites becomes dry, while that in the depressions remains moist. During periods of heavy rain, or in wet sites, the depressions may be filled with water, while the hummocks usually remain above the water.

Lejeune *et al* (1955) have shown that larvae in newly formed cocoons are easily killed by submersion. Therefore the location of the cocoons may affect the overwintering mortality. Heavy fall rains may raise the water table sufficiently to cause mortality of cocoons formed in the lower levels. A high water table in the spring delays emergence of adults from these lower levels, and prolonged high water levels will cause mortality.

This experiment was undertaken to determine if larch sawfly larvae aggregate in certain regions when exposed to a moisture gradient in the cocooning medium.

Methods and Materials

To simulate natural conditions the experiment was conducted under a tarpaulin shelter set up in a shady part of a mixed black spruce and tamarack bog (Fig. 1). This bog was located at Red Rock Lake, 11 miles north of Rennie, Manitoba. Racks were built under the shelter to hold wooden trays (12x48x9.5 inches) with screen bottoms (Fig. 2). The trays were set on these racks at a 15 per cent slope.

Sphagnum and non-sphagnum species of mosses, and muck soil, were gathered and spread out on bare rock to dry. When dry, the mosses were broken up with a carding device (Fig. 3) to give the material a relatively uniform texture. The mosses and soil were collected in areas free from tamarack to avoid contamination by old larch sawfly cocoons. Varying quantities of the dried materials were

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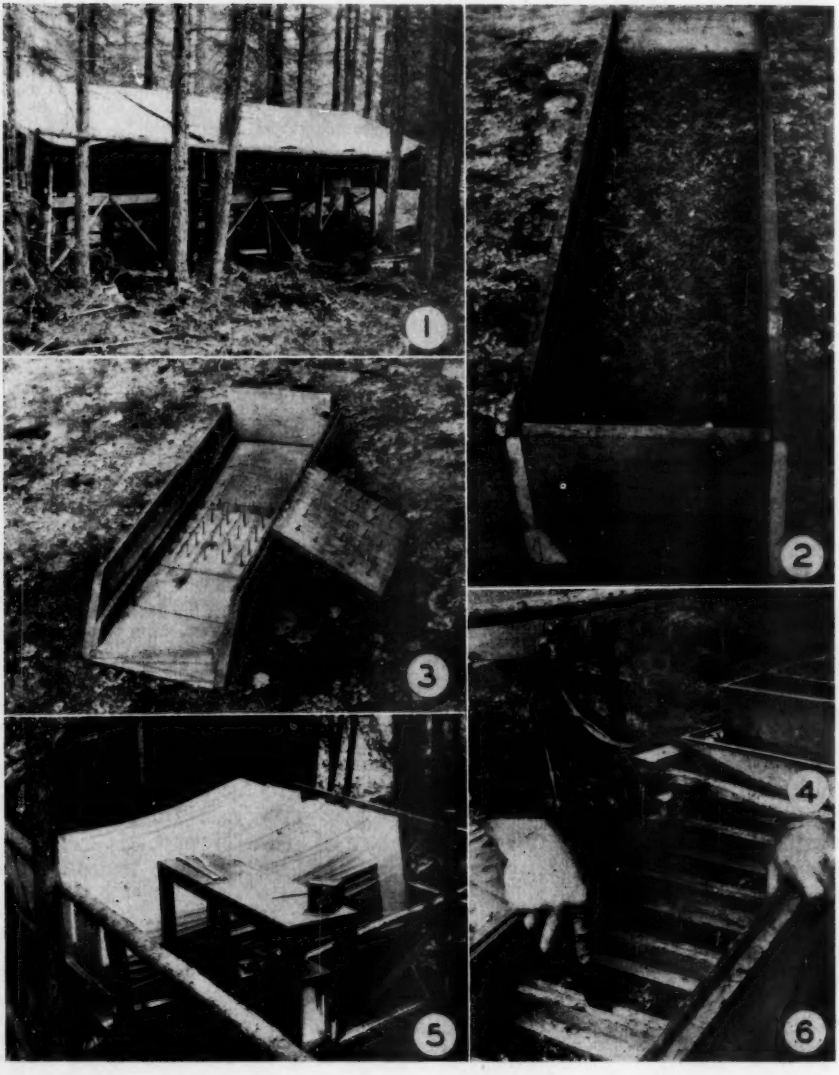

Figs. 1 to 6. 1. Tarpaulin shelter over experimental trays. 2. A wooden tray with cocooning medium in place. 3. Carding device used to break up the mosses. 4. Trays in position in pan of water. 5. Uniformly moist trays in position in plastic bags. Metal tray has drainage holes. 6. Guide used to cut across cocooning medium. A similar guide was used longitudinally. The two cut cocooning medium into six-inch square sections.

placed in four series of three trays each. The first series was filled to a depth of six inches with sphagnum mosses; the second with the same amount of non-sphagnum mosses; the third series with four inches of sphagnum mosses covering two inches of soil; and the fourth with four inches of non-sphagnum mosses covering two inches of soil.

In 1951 two of the three trays in each series were placed on the racks with their lower ends in large three-sided pans containing water (Fig. 4). The third member of each series was also placed in a pan, which was kept dry. The latter trays were to serve as checks to determine if the slope of the trays had any effect on larval aggregation. The water was kept at constant level in the pans by a slow, continuous addition of water from a connected tank (Fig. 4). The trays were left in the water for a week before larvae were added.

Fifth-instar larvae were collected in the field and fed until they dropped from the foliage. The larvae were then examined, and all larvae that appeared diseased or immature were rejected. A group of 100 mature larvae was released in each tray. During this operation a guide, divided into ten equal sections, was used to ensure a uniform distribution of the larvae. Wire screening was stapled over each tray to prevent rodents from entering and larvae from escaping.

Groups of larvae were released at approximately daily intervals, until a total of 500 had been released in each tray. A period of five days was then allowed to ensure the completion of cocooning.

The contents of the trays were then cut into six-inch square sections, using a sharp knife, and wooden guides (Fig. 6). Each section was removed carefully and divided horizontally into three equal subsections. Each subsection was placed in a paper bag for subsequent examination.

After the contents had been removed from the first set of trays, they were re-filled as before and the procedure repeated.

Examination of the check trays showed that the dry mosses were unfavourable for cocooning and that another method would have to be used to obtain a check.

The moisture gradient in the trays was determined separately from a third set, using one tray from each series. Free moisture content, expressed as percentage of dry weight, was determined on single samples in the field laboratory, using a Coleman stove and an oil-stove oven.

In 1954 a similar set containing four series of three trays each was set up as before, except that one of the trays in each series was divided in half along the longitudinal axis by a screen partition. The four divided trays were placed in a pan of water as before. One half of each tray was used for moisture determinations. Larvae were released in the other half, to give a rough check on the comparative larval behaviour for the two years. The wet weight of the mosses and soil was obtained in the field, but the air dry weight and percentage moisture were determined on duplicate samples in the main laboratory, using an electric drying oven.

The other two trays in each series were submerged until saturated with water. They were then placed in large untreated plastic garment bags on the racks and allowed to drain (Fig. 5). A can of water was placed inside each plastic bag, at the upper end of the tray, to maintain high humidity and to prevent drying of the contents. After one week larvae were released as described previously and counts made after cocooning had been completed.

Results and Discussion

The distribution of cocoons in the dry check, moist check, and moisture gradient series for sphagnum and non-sphagnum mosses are given in Figures 7 to 10. Each frequency is the mean of four observations for both of the check series, and of eight observations for the moisture gradient series. No cocoons were found in the soil. The two series with soil are therefore presented as containing four inches of mosses.

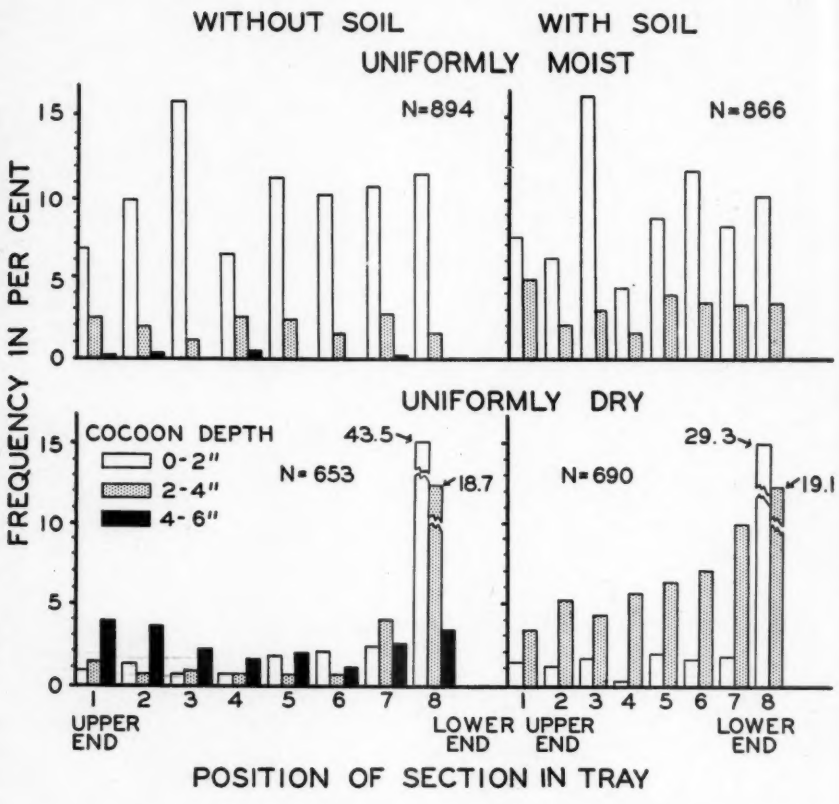

Fig. 7. Distribution of cocoons in sphagnum mosses for the uniformly moist and uniformly dry check series.

Uniformly Dry Check Series

The distribution of cocoons indicated that the dry mosses were very unfavourable for cocooning as considerable wandering occurred (Figs. 7 and 8). Nearly all the cocoons found in these trays were thin and white and many of the cocooned larvae were desiccated. The high frequencies encountered at the lower ends of the trays suggested that slope may have influenced the distribution of the larvae. This could render interpretation of the distribution of cocoons in the moisture gradient trays difficult or impossible. Because dryness rather than slope may have been the cause of the high concentration at the lower ends of the trays, the checks were repeated using uniformly moist conditions.

Uniformly Moist Check Series

The distribution of cocoons in the uniformly moist trays indicated a high degree of preference for the upper two inches of the cocooning medium. The average frequencies in per cent for the different levels were as follows:

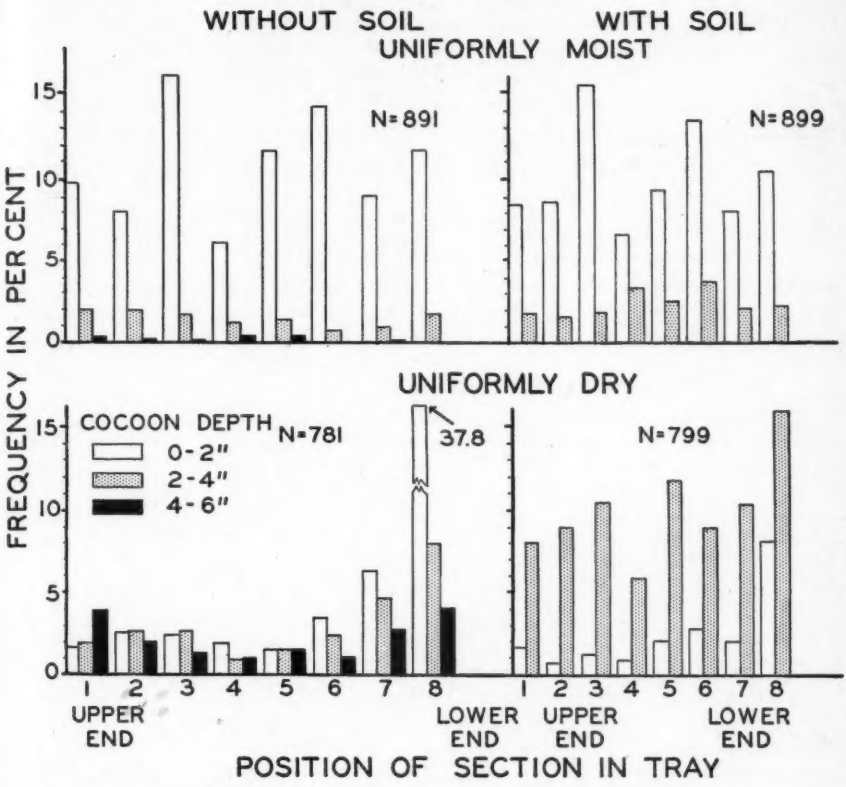

Fig. 8 Distribution of cocoons in non-sphagnum mosses for the uniformly moist and uniformly dry check series.

Cocooning depth in inches	Moss type			
	Sphagnum		Non-sphagnum	
	Without soil	With soil	Without soil	With soil
0–2	82.55	73.90	86.87	81.07
2–4	16.22	26.10	11.45	18.93
4–6	1.23	0.0	1.68	0.0

These frequencies indicate that the larvae do not penetrate into the medium very deeply if conditions are favourable for cocooning throughout.

Analyses of variance tests of the number of cocoons per section indicated significant differences in all cases. To find if the slope of the trays affected the cocooning sites chosen by the larvae an orthogonal comparison was made be-

tween Sections 1 to 4 vs. 5 to 8, where the sections are numbered consecutively from the upper to the lower ends of the trays. In order to obtain additional information from the available data orthogonal comparisons were also made between Sections 1 + 2 vs. 3 + 4, 5 + 6 vs. 7 + 8, 1 vs. 2, 3 vs. 4, 5 vs. 6, and 7 vs. 8. These additional comparisons were not foreseen in planning the experiment; therefore further data would be necessary to assess properly the significance of any differences revealed.

A portion of the results of these analyses is presented in Table 1.

No significant differences were found between Sections 1 to 4 vs. 5 to 8, indicating that the slope of the trays did not materially affect the location of the cocoons. One very noticeable feature was the consistent differences between

TABLE I.

Analyses of variance table for testing differences in number of cocoons per section.

Source	d.f.	Non-sphagnum mosses					
		Without soil			With soil		
		S.S.	M.S.	F.	S.S.	M.S.	F.
Trays	1	38.28	38.28	1.67	0.00	0.00	0.00
Positions	7	1478.47	211.21	9.22**	1367.38	195.34	21.41**
(Comparisons of positions							
1 to 4 vs. 5 to 8	1	30.03	30.03	1.31	40.50	40.50	4.44
3 vs. 4	1	1081.12	1081.12	47.20**	544.50	544.50	59.67**
Rest	5)	367.32	73.46	3.21*	782.38	156.48	17.16**
Interaction	7	80.97	11.57	0.50	170.50	24.36	2.67
Error	16	366.50	22.91		146.00	9.12	
Total	31	1964.22			1683.88		

Source	d.f.	Sphagnum mosses					
		Without soil			With soil		
		S.S.	M.S.	F.	S.S.	M.S.	F.
Trays	1	0.12	0.12	0.00	3.12	3.12	0.09
Positions	7	864.88	123.55	3.37*	2220.38	317.20	8.75**
(Comparisons of positions							
1 to 4 vs. 5 to 8	1	45.12	45.12	1.23	153.12	153.12	4.22
3 vs. 4	1	595.12	595.12	16.25**	1653.12	1653.12	45.60**
Rest	5)	224.64	44.93	1.23	414.14	82.83	2.28
Interaction	7	170.88	24.41	0.67	210.38	30.05	0.83
Error	16	586.00	36.62		580.00	36.25	
Total	31	1621.88			3031.88		

*Significant at .05 level.
**Significant at .01 level.

Sections 3 and 4 for all sets of trays. No satisfactory explanation can be given for the high frequency encountered in Section 3. No moisture determinations were made but the appearance of the mosses indicated a uniform moisture content. Therefore, it is doubtful if moisture was the factor responsible for this phenomenon. In the trays containing non-sphagnum mosses further significant differences were encountered, but these have no bearing on the effect of slope and will not be discussed.

Moisture Gradient Series

The frequency of cocoons from the 1951 data and the moisture content of the cocooning medium in the moisture gradient series are shown in Figures 9 and 10. The moisture contents are expressed as percentage of dry weight and are based on the 1954 determination with the exception of Sections 1 to 4 of the sphagnum medium with soil. In this case the shaded areas represent the 1951 determinations, while the 1954 figures are shown by the dotted outlines. The 1951 figures were used here because excessive moisture absorption occurred in the upper end of the tray containing sphagnum mosses and soil in 1954, and the 1951 figures are probably more reliable. This emphasizes that the percentage moisture determinations only approximate the conditions that prevailed at the time of cocooning. A horizontal and vertical moisture gradient occurred to some degree within each subsection. The figure obtained in the moisture determinations is an average of the moisture for each subsection. Furthermore, conditions governing the fluctuations in the moisture gradient in the trays used for moisture determinations may have differed slightly from those in which the larvae were cocooning. The texture of the medium, relative humidity, and temperature could all affect the moisture balance. This applied especially to the sphagnum mosses, which were sensitive to temperature and humidity changes. The moisture contents given are sufficiently accurate to provide a basis for the graphic interpretation presented here, but it is doubtful whether regression methods would be applicable. The distribution of cocoons in relation to moisture will be discussed separately for the non-sphagnum and sphagnum mosses.

Non-sphagnum

The distribution of cocoons indicated that both dry sites and sites containing over 1500 per cent moisture were unfavourable for the formation of cocoons. The response in the intermediate moisture ranges will be discussed separately for the trays with and without soil.

The highest concentrations of larvae in the trays without soil occurred in Subsection 4.3. and 5.2. (Section 4, 4-to 6-inch depth and Section 5, 2-to 4-inch depth). These subsections are probably no more favourable for the formation of cocoons than Subsections 6.1., 6.2. and 7.1., since larvae from the drier parts of the trays would presumably concentrate at the first suitable cocooning site encountered, even if other sites are equally suitable. The range in moisture content that appears favourable for the formation of cocoons is from about 300 to 850 per cent of dry weight. The larvae apparently penetrated the cocooning medium and wandered through the moss until favourable conditions were encountered, rather than crawling over the surface. This is demonstrated by the high frequency found in Subsection 4.3.

In the trays containing soil, the highest frequency occurred in Subsection 3.2. which contained about 200 per cent moisture. However, the cocoons were found at the bottom of the subsection, next to the soil, where the mosses had the highest moisture content. A similar condition existed in Subsection 4.2.

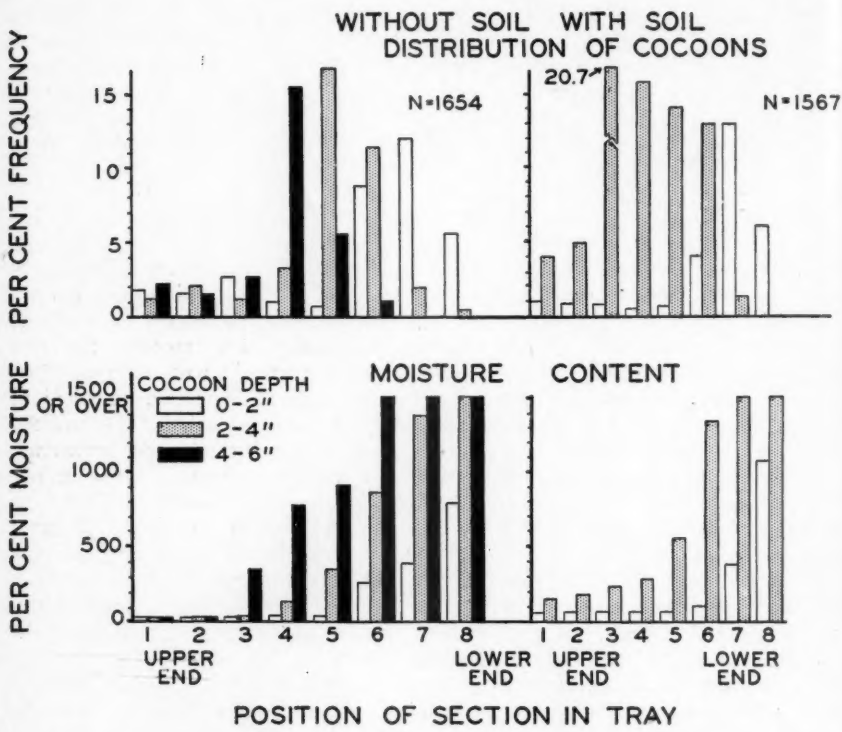

Fig. 9. Distribution of cocoons and moisture content of mosses in the non-sphagnum moisture gradient series. Percentage of moisture based on 1954 determinations.

Subsections 5.2., 6.2., and 7.1. all appear equally favourable for cocooning, but the number of cocoons was lower than in Subsection 3.2. The larvae again appear to have penetrated into the moss and crawled through the moss until a favourable site was reached. The lower side of Subsection 6.2. was submerged, and the cocoons found in this subsection were probably formed in the upper drier portion. Therefore, although the moisture content for the subsection was about 1300 per cent, the moisture content for the upper portion of the subsection would be considerably lower. The moisture requirements of the larvae were not very critical, as before, and a moisture range of from about 300 to 850 per cent of dry weight was again favourable for cocooning.

Although the above moisture ranges are quite wide, it is possible that the humidity of the air in the space in the mosses may be fairly uniform over this moisture range. Since the larval reaction may be determined in part by humidity (or evaporation), the cocooning conditions in terms of humidity may actually be more critical than are indicated by the moisture ranges.

Sphagnum

Cocoon distribution in the sphagnum mosses differed from that in the non-sphagnum mosses in the low frequency of cocoons in the 4 to 6 inch depth.

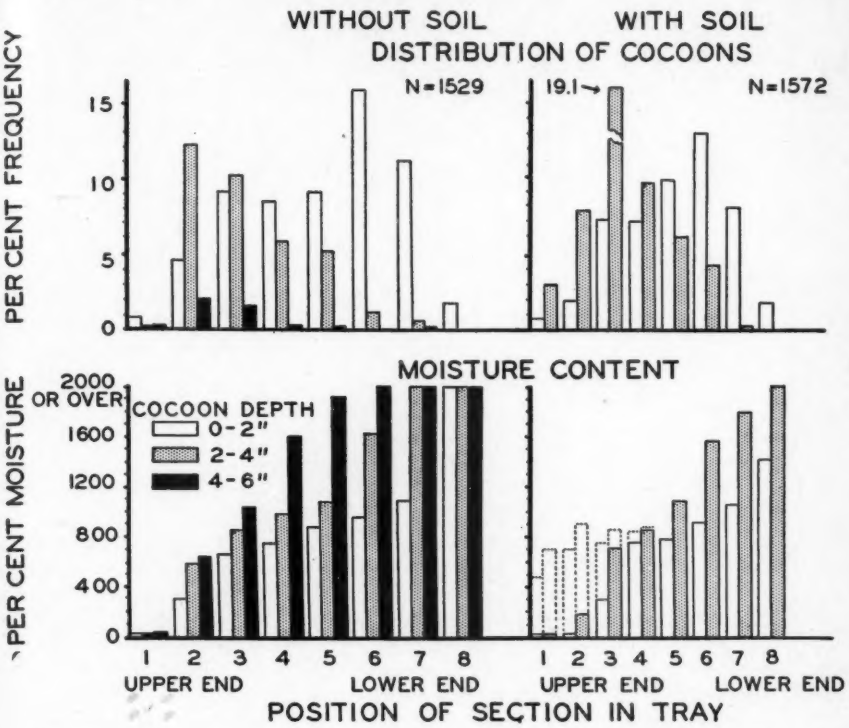

Fig. 10. Distribution of cocoons and moisture content of mosses in the sphagnum moisture gradient series. All bars showing percentage of moisture represent 1954 determinations excepting those in the histogram for moisture content of moss with soil, where in Sections 1 to 4 the 1954 determinations are given by dotted outlines and the 1951 figures by shaded areas beneath.

Very few cocoons were found in the subsections that were very dry or very wet. As in the non-sphagnum series a concentration of cocoons was found in Subsection 3.2. in the trays with soil. These points further support the hypothesis that larvae cocoon in the first favourable site encountered.

In the sphagnum mosses the most favourable moisture range was from 500 to 1000 per cent of dry weight. This is a wide range, further substantiating the hypothesis that the moisture requirements are not too critical.

Comparison of Larval Behaviour in 1951 and 1954

The foregoing discussion on larval behaviour in the moisture gradient trays has been confined to the 1951 data. To provide a crude comparison of the behaviour of the larvae in 1951 and 1954 the subsections were grouped by approximate moisture contents and a t-test for grouped comparisons used to test for differences between the two years within these classes. The results of these tests are given in Table 2.

This is a crude test, as the 1954 data are limited, and the overall significance of the tests is difficult to assess. However, it appears that there was less response to moisture by the larvae on the dry sections of the trays in 1954. This apparent

TABLE 2.

A comparison of the mean number of cocoons per subsection in 1951 and 1954, grouped by moisture content, using "Student's" t for group comparisons.

Type of moss	Moisture class (%)	No. sections	Mean no. cocoons		d.f. for t	t
			1954	1951		
Sphagnum..... without soil....	15–50	3	3.67	0.71	25	2.78*
	50–1000	9	17.44	16.43	79	0.28
	1000–1400	3	7.67	11.33	25	–0.56
Sphagnum..... with soil.....	15–50	3	10.67	3.58	25	3.02**
	50–1000	6	16.67	19.98	52	–0.64
	1000–1400	3	27.33	17.79	25	1.74
Non-sphagnum... without soil....	15–50	10	6.20	3.21	88	2.79**
	50–800	7	19.57	18.95	61	0.11
	over 800	3	5.00	14.86	25	–1.34
Non-sphagnum... with soil.....	15–50	6	9.83	2.42	52	4.44**
	50–800	6	17.50	23.58	52	–1.04
	over 800	3	19.00	13.21	25	0.90

*Significant at .05 level.
**Significant at .01 level.

difference may have been caused by slight differences in the moisture content of the mosses. It is also very likely that the differences noted may be due to differences in pre-conditioning of the material in the two years, and that the same effect would be expected in simultaneous tests where a difference in conditioning of the larvae occurred. However, the observed difference does indicate the possibility that the larval response to moisture may vary slightly from year to year.

Summary

A method is described for determining if mature larch sawfly show a moisture preference for cocooning sites when exposed to a moisture gradient, and for studying their distribution when allowed to cocoon under uniformly dry and uniformly moist conditions. Larvae were released uniformly over the surface of wooden trays containing cocooning medium and permitted to cocoon.

The uniformly dry conditions were found to be unfavourable for cocooning. A considerable amount of wandering occurred under these conditions and the cocoons that were formed were poorly constructed.

The larvae that were exposed to uniformly moist conditions cocooned near the surface, and did not wander to any extent.

The distribution of cocoons formed by larvae that had been exposed to a moisture gradient showed that dry and very wet sites were unfavourable for cocooning. Moisture was a factor in determining where cocoons were formed, although the favourable moisture ranges were quite wide. These ranges were from 300 to 850 and from 500 to 1000 per cent of dry weight for non-sphagnum and sphagnum mosses respectively.

Acknowledgments

I wish to thank Mr. R. R. Lejeune, Officer-in-Charge, Forest Biology Laboratory, Winnipeg, for suggesting this problem. My sincere thanks are also

extended to my research colleagues at the Winnipeg laboratory, for their many helpful suggestions and criticisms while the manuscript was in preparation, and to Mr. B. B. McLeod for preparing the graphs.

Reference

Lejeune, R. R., W. H. Fell and D. P. Burbidge. 1955. The Effect of Flooding on Development and Survival of the Larch Sawfly (*Pristiphora erichsonii* (Hartig)) (Tenthredinidae). Ecology, 36: 63-70.

The Bark Beetle Complex Associated with Lodgepole Pine Slash in Alberta[1]

Part 1—Notes on the Biologies of some Scolytidae attacking Lodgepole Pine Slash

By R. W. Reid

Introduction

This investigation was carried out to determine and explain some of the major factors underlying the variability in concentration of certain bark beetles in slash laid down under different cutting systems. Little is known on the life histories and natural control factors of many of the bark beetles inhabiting lodgepole pine (*Pinus contorta* Dougl. var *latifolia* Engelm.) and on the effect which different methods of logging have on the insects. Flash outbreaks in lodgepole pine stands frequently result from the breeding of certain bark beetles in slash remaining after logging operations. The opportunity to carry out this investigation was presented to the Calgary Laboratory in 1952, when the Federal Forest Service initiated studies on selectively cut lodgepole pine. This eventually became a co-operative project between the Federal Forest Service, Department of Northern Affairs and National Resources, and the Calgary Laboratories of Forest Zoology and Forest Pathology of the Division of Forest Biology.

The experimental area is located approximately 20 miles southwest of Rocky Mountain House, Alberta, within the region termed by Halliday (1937) the "B 19 or foothills section" of the Boreal Forest. Of nine 10-acre blocks in an 84-year-old stand eight were cut under the following different systems: sanitation cut, thinning from above, thinning from below, clear cutting, shelterwood, diameter limit, patch logging, seed tree: one block was left as a control. The logging was done by a private company under the direction of the Federal Forest Service. The objective of the Forestry study is the improvement of management practises for this timber type.

Results from the entomological portion of the investigation will be presented in a series of four papers of which the present contribution is the first: I—Notes on the biologies of some Scolytidae attacking lodgepole pine slash; II—Notes on the biologies of the associated parasites; III—Notes on the biologies of associated predators; IV—Distribution and populations of the scolytids, predators, parasites and the effect of several environmental factors.

This paper deals with the seasonal history and habits of the most common bark-beetles found attacking lodgepole pine slash. The seasonal histories described here were determined during the 1952 and 1953 field seasons. The following species were found attacking slash in the experimental area: *Ips perroti* Sw.; *Ips*

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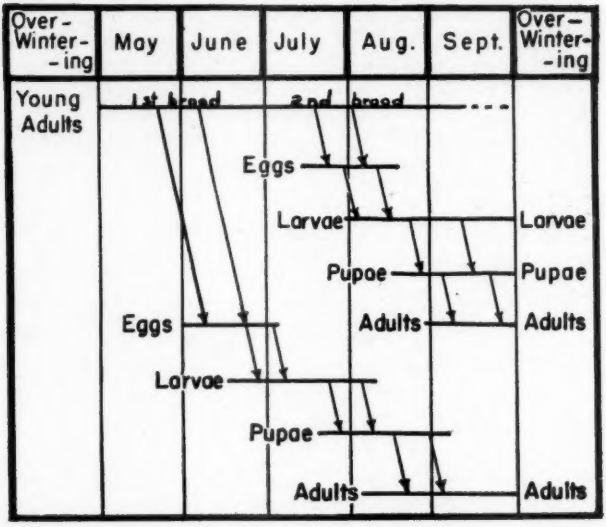

Fig. 1. Representation of seasonal history of *Ips perroti* Sw.

pini Say; *Ips guildi* Blk.; *Pityogenes knechteli* Sw.; *Orthotomicus vicinus* (Lec.); *Polygraphus rufipennis* Kby.; *Hylurgops rugipennis* (Mann.); *Dendroctonus valens* Lec. No *Dendroctonus monticolae* Hopk. were found. Several scolytids of other genera were present but in very low numbers.

Ips perroti Sw.

The presence of this small scolytid was surprising because Swaine (1918) reported it as an eastern species, rare, and with a very limited distribution. S. L. Wood of the Systematic Entomology Unit identified the specimens from Alberta and writes that this species was previously known only from a few dozen specimens. These were taken from red pine in Eastern Canada and from jack pine in Minnesota. Collections of *Ips perroti* from several areas on the eastern slopes of the Rocky Mountains, including the experimental area, indicates a much wider distribution than was previously realized. Its distribution in the Boreal Forest likely parallels that of *Ips pini* Say.

Life Cycle:

Ips perroti overwinters as young adults and less commonly as pupae and larvae. The seasonal development during 1952 is illustrated diagramatically in Fig. 1. During that season, adults were noticed in flight and establishing broods from the first of June to the middle of August. Brood establishment reached a peak during mid June to the end of July. Adults from caged logs infested in early June, left their initial broods and established second broods commencing in mid July and continuing to mid August. Some old adults were found dead at the end of the second brood gallery but it is not known definitely how long they live. Teneral adults from the first brood were common from early August to September. During that period they fed extensively under the bark near their pupal chambers. The proportion of insects overwintering as larvae and pupae depends upon the time of brood establishment and rate of development through

the summer months which in turn is related directly to the prevailing weather. During 1952, to which Fig. 1 refers, the mean maximum temperature in April was 57.5°F. and in May 63.1°F. as opposed to April and May of 1953 when mean maximums were 42.2°F. and 59.4°F. respectively. *Ips perroti* and *Ips pini* were moving in the area and establishing broods in 1952 from two to three weeks earlier than in 1953; as a result teneral adults appeared earlier and there were fewer larvae and pupae in the fall than in 1953.

Gallery pattern and habits:

The method of gallery establishment follows closely that described by Clemens (1916) for *Ips pini* Say. The males make the initial entry hole and excavate a cylindrical burrow at an oblique angle through the bark to the sapwood. The nuptial chamber, varying from triangular to oval, is constructed. When this has been completed several females enter and construct individual egg galleries. The species is polygamous and the number of egg galleries radiating from each nuptial chamber varies from two to five, the most frequent being three. The gallery pattern is illustrated in Fig. 2. Mating takes place within the nuptial chamber. As the female elongates its gallery, it excavates minute egg niches and places an egg in each niche; it then packs in boring dust until the opening is filled even with the wall of the gallery. This packing is referred to as the egg-niche plug. The eggs are laid at closely spaced intervals usually along both sides of the gallery.

The nuptial chamber and egg galleries are kept clear of frass and boring dust. The female removes this material from the egg gallery by rotating its body within the gallery and retreating backwards to the nuptial chamber; the male then pushes this material out the entry hole where the accumulated brown boring dust becomes conspicuous.

Instead of moving away from the egg galleries, as in most *Ips* species, larvae enlarge pockets adjacent to these galleries. The woody tissue surrounding these pockets, and the accumulated frass within the pockets become heavily impreg-

Fig. 2. Gallery pattern of *Ips perroti* (a—nuptial chamber, b—egg gallery, c—pupal chamber).

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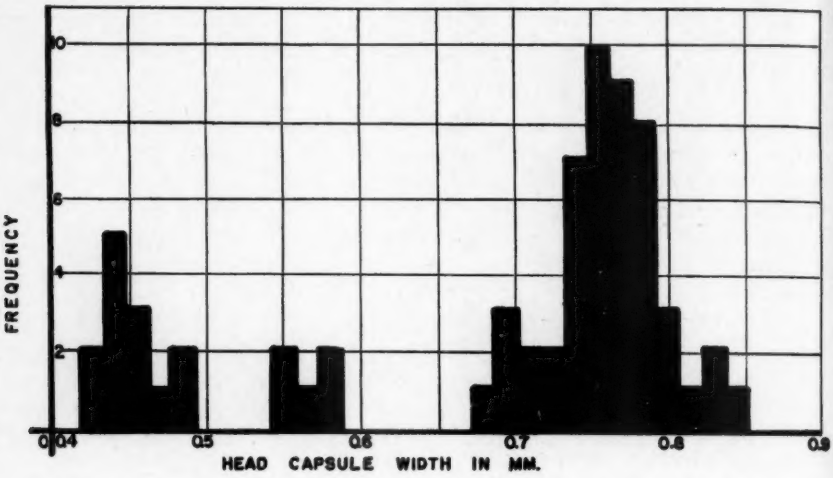

Fig. 3. Histogram illustrating larval head-capsule measurements *Ips perroti* Sw.

nated with a blue stain fungus and field observations suggest a symbiotic relationship between developing larvae and fungus. Pupation occurs within the pocket.

The histogram representing head-capsule measurements (Fig. 3) indicates three larval instars. Young adults may overwinter in the duff or under the bark depending on their degree of maturity at the onset of cool fall weather. The survival of larvae and pupae through an average winter in this region of the experimental area is very low and for this reason their development during the following year has not been discussed. In 1953, the majority of *Ips* emerged from the duff during the latter part of May and the first week of June. Entry into the duff took place during the last two weeks of September. The beetles drop almost directly into the duff when they leave the slash.

Ips pini Say.

This species is widely distributed throughout the range of the Boreal Forest (Swaine 1918, Chamberlin 1939). Clemens (1916) described the egg, larva, pupa, and habits of this species from the vicinity of Ithaca, New York. A description of the adult has been presented by Swaine (1916) and the synonymy listed by Swaine (1909). Thomas (1952) has described the external morphology.

Life Cycle

The life cycle of *Ipi pini* is very similar to that of *Ips perroti.* During 1952 and 1953 they varied only in time of appearance in the spring. The life cycle as shown in Fig. 1 conforms to that of *Ips pini* closely when all stages of *Ips perroti* are moved back approximately 14 days. If spring weather similar to that of 1952 were followed by a warm dry summer, two generations of *Ips pini* per year might occur.

Gallery pattern and habits

Ips pini constructs its gallery as illustrated in Fig. 4. The larvae, on hatching from the eggs, commence mining at right angles to the egg gallery. The larvae

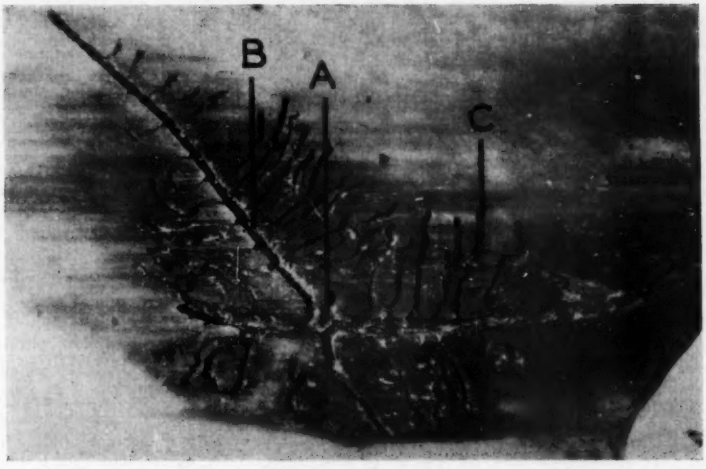

Fig. 4. Gallery pattern of *Ips pini* Say (a—nuptial chamber, b—egg gallery, c—larval gallery).

take a serpentine course through the subcortex and cambium, and the galleries increase in size as the larvae develop. Pupal chambers, partly in the sapwood and partly in the inner bark, are constructed at the ends of the larval galleries. The pupal chamber is sealed off with frass.

The measurements of a number of head capsules indicate that there are three instars (Fig. 5). This agrees with Prebble (1933). Head capsules for corresponding instars measure somewhat larger in *pini* than in *perroti*.

Life cycles differ between seasons and between regions depending on weather variations. Clemens (1916) reported *Ips pini* produced two and under

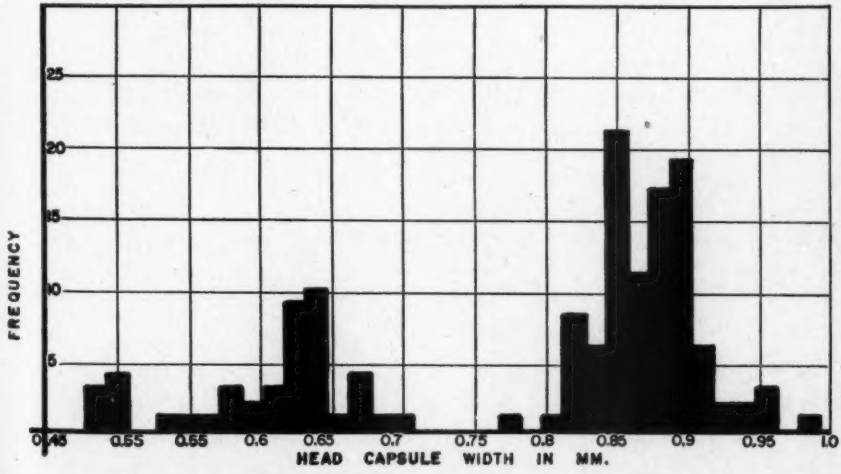

Fig. 5. Histogram illustrating larval head-capsule measurements *Ips pini* Say.

favourable conditions, three generations per year in the vicinity of Ithaca, New York. In Fredericton, New Brunswick, Prebble (1933) reported a period of 31 days from egg to adult in logs within cages exposed to full sunlight and 48 days in caged logs under moderate shade. Parent adults in exposed cages established up to four broods per season, those in moderate shade produced up to three broods per season. Thomas (1952) found that brood development was completed in 30 to 35 days near Laniel, Quebec . Parent adults produced up to two broods a season and only one generation per year occurred. In 1952, development from egg to adult required about 60 days on the experimental area at Strachan, Alberta.

Overwintering habits of this species also vary in different regions. Clemens (1916) records adults overwintering only under the bark. Dodge (1938) reports that Orr observed *Ips pini* overwintering as adults in the litter at the base of the brood tree. Overwintering habits of *Ips pini* in the experimental area are similar to those described earlier for *Ips perroti*, i.e., adults overwinter either in the duff directly below slash or under the bark. Overwintering adults from standing trees were found in the duff at the base of the trees. Whether adults overwinter in the duff or under the bark depends on their degree of maturity prior to cool weather in the fall.

A bark-beetle susceptible tree, as a unit, offers a choice of environment and it is apparent that certain species are adapted to certain sections of that unit. Hopping and Beall (1948) observed during the Banff Park outbreak of the mountain pine beetle (*Dendroctonus monticolae* Hopk.), that there appeared to be a relationship between tree susceptibility and tree diameter. In Sweden, Trägårdh (1938) found attacks by the spruce bark beetle (*Ips typographus* Linn.) decreased in proportion to decrease in diameter of the tree in an arithmetic series Graham (1952) illustrates graphically the sequence of bark-beetle attacks frequently occuring on yellow pine (*Pinus ponderosa* Laws) and shows the relative position occupied by the several species involved. On standing trees in the experimental area, *Ips pini* broods were found mainly below the crown level, and more abundant on the lower portions of the main stem. The scolytid association, including *Ips pini*, at different levels varied with intensity of attack and diameter of stem, but can be roughly described as follows: extreme base to height of one foot–*Dendroctonus murrayanae* Hopk., *Dendroctonus valens* Lec., *Hylurgops rugipennis* (Man.); main stem to crown level–*Ips pini* Say, *Ips guildi* Blk., *Orthotomicus vicinus* Lec.; crown section–*Pityogenes knechteli* Sw., *Polygraphus rufipennis* Kby.

Ips guildi Blk.

This bark-beetle, closely related to *Ips latidens* Lec., was found on the lower stem of standing trees but no evidence of its occurrence in slash or stumps was observed. Overwintering adults were recovered from duff samples taken at the base of infested trees. Some overwintering larvae were collected from galleries.

Little information is available on the life history or habits.

Pityogenes knechteli Sw.

This species is associated with small diameter slash and stems. It was described by Swaine (1918) from lodgepole pine in Alberta and British Columbia. Chamberlin (1939) reports western white pine as a host and distribution extending into the northwestern United States.

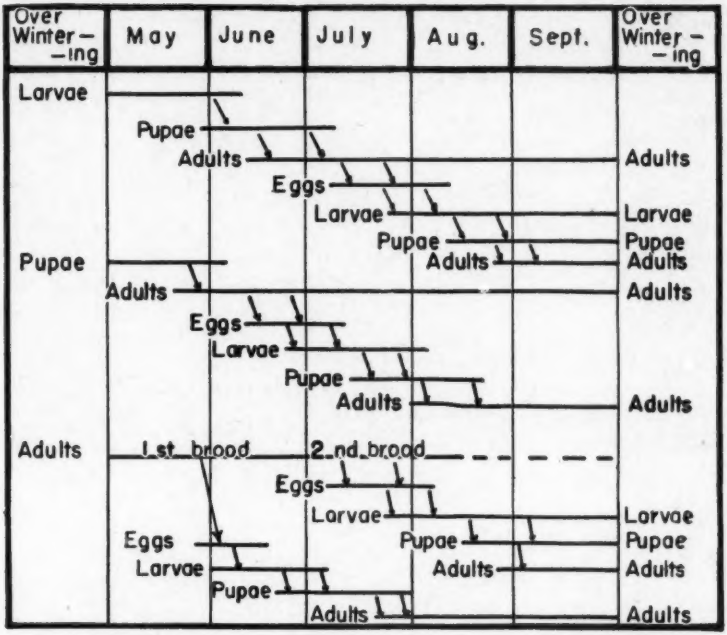

Fig. 6. Representation of seasonal history of *Pityogenes knechteli* 1953.

Life cycle

The life cycle, as determined from field observations and cage work in 1953 is illustrated diagramatically in Fig. 6. No cage records are available on the development and behaviour of overwintering larvae or pupae but field observations indicate the development as shown in Fig. 6. These immature forms commonly overwinter and appear to survive the low temperatures much more successfully than *Ips pini* or *Ips perroti*.

In 1953, the first strikes by this species were observed during the last week in May. Portions of slash containing these strikes were placed in rearing cages where the brood development and adult behaviour could be more closely watched. Commencing the first week of July and extending to the first week of August, a number of the original caged adults established second broods. Teneral adults from the first brood appeared in mid July and fed extensively under the bark until fall. By September the second brood was mainly in the larval and pupal stage, with a small percentage of teneral adults.

Not all the overwintering adults produced two broods during the 1953 season. As it cannot be assumed that all adults were of the same age, it is suggested that those dying after establishment of only one brood in 1953 were adults which overwintered (1951-52) as larvae or pupae and established only one brood in the 1952 season.

Gallery pattern and habits

The gallery pattern characteristic of this polygamous species is shown in Fig. 7. This photograph was taken before the eggs had hatched. The number

Fig. 7. Gallery pattern *Pityogenes knechteli* (a—nuptial chamber, b—egg gallery, c—egg niche).

of egg galleries varies from four to six per strike. Egg counts in 19 strikes averaged 59 per strike. Thirteen freshly laid eggs, subjected to normal air temperatures hatched in from 9 to 13 days.

Construction of the nuptial chamber and egg galleries by *P. knechteli* follows closely that described by Blackman (1915) for *P. hopkinsi* Sw. The nuptial chamber and egg galleries are constructed within the soft inner bark and the sapwood is engraved very slightly. Larval mines are confined mainly to the inner bark until the larvae reach maturity. Pupation takes place within small pits completely in the sapwood, shallow excavations within the sapwood and inner bark, or in pupal cells within the inner bark.

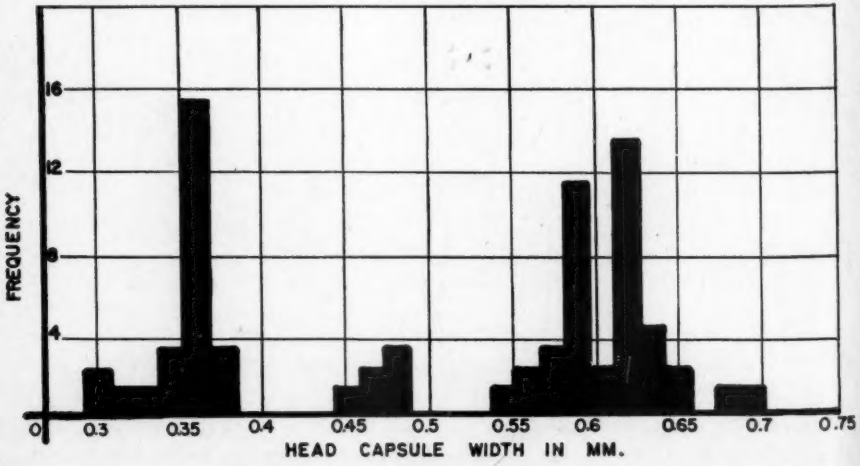

Fig. 8. Histogram illustrating larval head-capsule measurements *Pityogenes knechteli*.

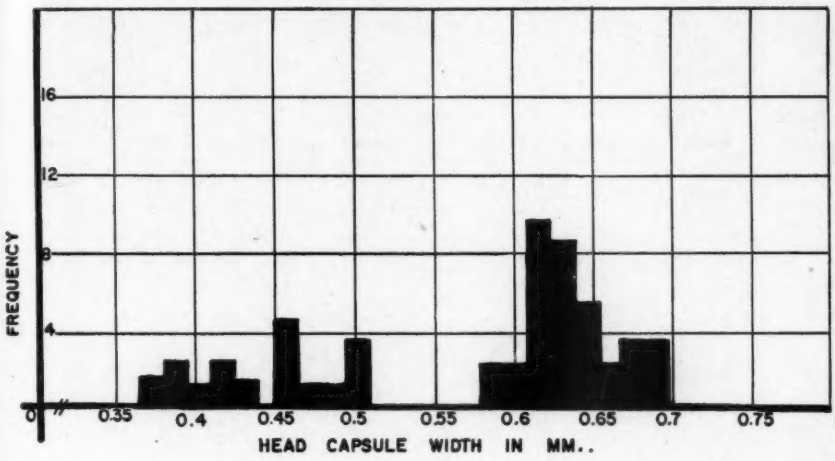

Fig. 9. Histogram illustrating larval head-capsule measurements *Orthotomicus vicinus*.

Head-capsule measurements, (Fig. 8), indicate 4 and possibly 5 instars. Blackman (1915) found that *P. hopkinsi* passed through 5 instars.

***Orthotomicus vicinus* (Lec.)**

This species, according to Swaine (1918) is a western form of *Orthotomicus caelatus* (Eich.), the distribution for *O. vicinus* being from Manitoba west to British Columbia, Yukon, and south in the Rocky Mountains to Colorado (Chamberlin 1939).

Orthotomicus vicinus has a life cycle and gallery pattern similar to *P. knechteli*. Within the experimental area, this insect was found almost entirely in fresh stumps or the lower stems of large standing trees. It was very seldom found in slash. Blackman (1922) and Thomas (1952) reported *O. caelatus* as having similar preferences.

The adult galleries and larval mines are scored in the sapwood slightly deeper than those of *Pityogenes* and the radial character of the gallery is not so pronounced. Pupation takes place in chambers constructed in the inner bark, or within pits in the sapwood. *Orthotomicus* tends to make deeper pits in the sapwood, with the circular entry hole proceeding directly in, whereas *Pityogenes* tend to slope the entry hole. The holes are plugged with fibrous boring dust and the pupal cell is an elongated chamber, running parallel with the grain of the wood. These holes penetrate one-eighth inch into the sapwood.

Head capsule measurements indicate 3 instars (Fig. 9). The hatching period of 7 freshly laid eggs subjected to normal air temperatures varied from seven to twelve days. Two eggs per egg niche are common

***Polygraphus rufipennis* Kby.**

Swaine (1918) refers to this species as "abundant throughout the spruce forests of Canada and the Northern United States from the Pacific coast east to Newfoundland". Within the experimental area, *Polygraphus rufipennis* was found in lodgepole pine slash of small diameters.

Fig. 10. Gallery pattern of *Polygraphus rufipennis* (a—nuptial chamber, b—egg gallery, c—larval gallery).

Adults inhabiting caged slash, which was infested the latter part of June 1953, established a second brood commencing the last week of July. The first brood overwintered as adults and the second brood as larvae and to a lesser extent as pupae. Simpson (Swaine 1929) followed the life cycle of this species very carefully in New Brunswick and observed the establishment of three broods in one season and a fourth brood the following spring by one pair of adults.

Polygraphus rufipennis adults attacked fresh lodgepole pine slash mainly in pairs or threes. One or at the most two egg galleries were constructed from the nuptial chamber as illustrated in Fig. 10. Nuptial chambers and egg galleries are deeply engraved in the sapwood. Eggs are laid two or three deep, along the sides of the egg gallery and packed in securely with boring dust. The larvae work away from the egg gallery, mining individual tunnels. Pupation occurs in shallow depressions lightly engraved into the sapwood at the end of the larval galleries.

Hylurgops rugipennis (Mann.)

A brief description of this insect is supplied by Swaine (1918) and Chamberlin (1939). Swaine (1918) reports the range as extending from Alaska to California and Keen (1952) extends the range to include the northern Rocky Mountain region. Host trees include the pines, the spruces, Douglas fir, western hemlock.

Life Cycle

The life cycle is shown diagramatically in Fig. 11. A large number of attacks were made by this species in the spring and early summer of 1952. In September most of the progeny, except for a small percentage that had pupated, were in the larval stage. The broods remained, for the most part, as larvae during the summer of 1953 and some spent the second winter in this stage. During late summer of 1953 most had become pupae and some had reached the

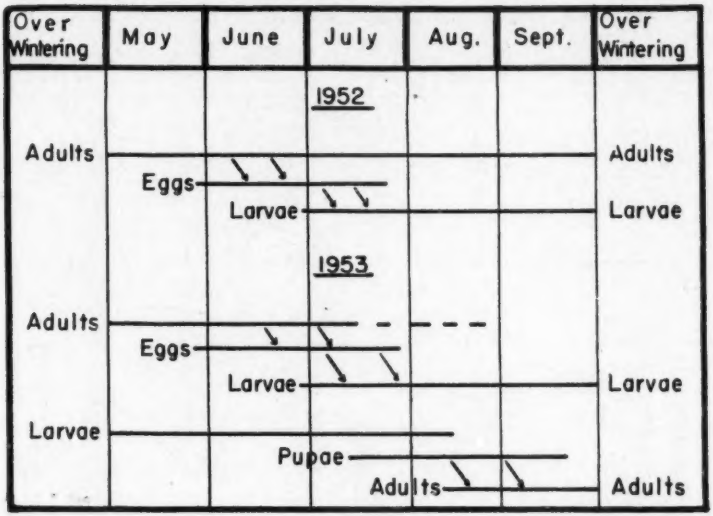

Fig. 11. Representation of seasonal history of *Hylurgops rugipennis*.

young adult stage. Young adults commonly emerged but were not observed to establish broods that year.

Fig. 11 shows that new broods were established in 1953. It was not observed whether these broods were the result of new adults flying into the area or a second brood by the original adults in the area in 1952. Although the life cycle of the main population is as illustrated, portions of a single brood may differ considerably in rate of development. The life cycle varies from 1½ to 2½ years, resulting in a flight period of adults throughout a good part of the summer. Possible reasons for this staggering in the life cycle will be enlarged upon in the section following.

Gallery pattern and habits

Adults attack the base of stumps in pairs, just above the duff. The adult galleries run several inches above and below the entry hole. Eggs are deposited within shallow depressions along the sides of the galleries, from one to five in depth and packed in with boring dust.

In the early stages the entire brood works down from the egg gallery in one large group. Later they become separated into smaller groups, and by the time the larvae have reached maturity they can be found singly or in groups of two to six. Larvae have been found along the large lateral roots several feet from the egg gallery. Larvae also work down the tap root well into mineral soil. If competition is not too severe, some larvae remain working in subcortical regions at the upper duff level.

Head-capsule measurements illustrated in Fig. 12 indicate four larval instars. The first three instars and a few of the fourth were collected during the 1952 season. Fourth-instar larvae persisted throughout most of the following summer.

Temperatures differ considerably in the subcortical regions where the larvae work. Bark temperatures on main lateral roots, at various depths below the

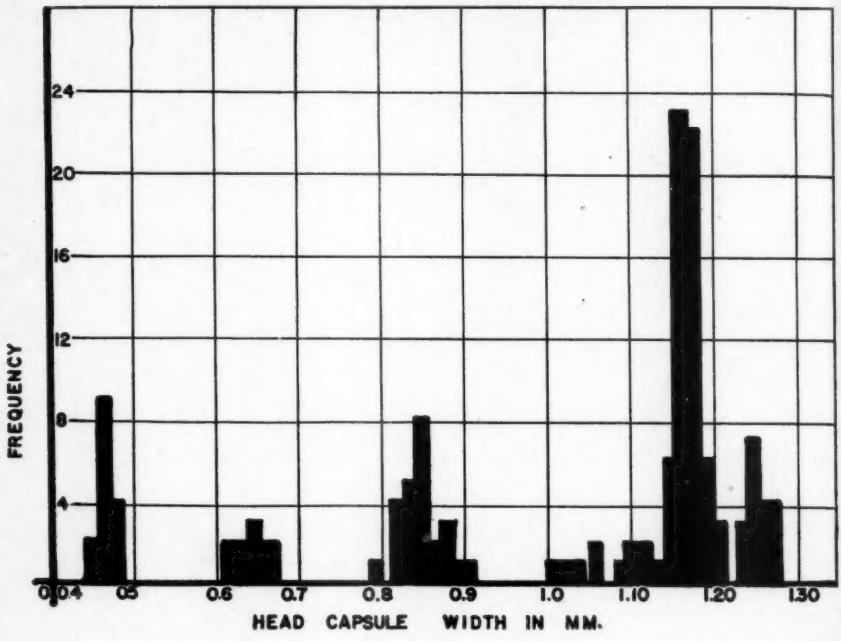

Fig. 12. Histogram illustrating larval head-capsule measurements of *Hylurgops rugipennis*.

upper level of the duff were taken on two exposed trees on different days. A Rubicon potentiometer and number 30 gauge copper-constantan thermocouple leads, attached to the outer surface of the bark, were used to record the temperatures. Recorded temperatures are given in Table 1.

TABLE I

Root Surface Temperatures at Various Levels (°C).

Location of lead	Tree No. 1		Tree No. 2	
	South Aspect	North Aspect	South Aspect	North Aspect
Air Temp.	22.5	22.8	24.5	22.5
Surface of duff	39.0	21.5	45.5	21.5
1 inch below surface	24.5	15.5	26.0	14.5
2 inches " "	17.5	15.0	21.0	14.5
4 " " " (lower level of duff)	14.0	13.0	17.0	14.0
6 " " "	12.3	13.0	13.0	12.5

It is common to find larvae of a single brood scattered from duff level well into mineral soil. An extended flight period, and the appearance of adults each year even though the species generally has a two-year cycle, seems to be a common feature of many root inhabiting forest insects. The contrasts in temperature within subcortical regions and the resultant differences in rate of development are probably responsible.

***Dendroctonus valens* Lec.**

This widely distributed species was common within fresh stumps on the experimental area.

Its method of attack, gallery pattern, and habits are well described in the literature (Swaine 1918, Chamberlin 1939). Its life cycle in the experimental area was similar to *Hylurgops rugipennis*, i.e., it varied from one and a half to two and a half years.

Acknowledgments

The assistance of various members of the Calgary Forest Zoology Laboratory is gratefully acknowledged.

Appreciation for identifying the scolytids is expressed to G. R. Hopping, Officer-in-Charge of the Calgary Forest Zoology Laboratory, and S. L. Wood of the Unit of Systematic Entomology, Division of Entomology, Department of Agriculture, Ottawa.

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(Received May 5, 1955)

FIRST ANNOUNCEMENT

TENTH INTERNATIONAL CONGRESS OF ENTOMOLOGY

MONTREAL, CANADA, 1956

President, Dr. W. R. Thompson
Secretary, Mr. J. A. Downes
Associate Secretary, Dr. W. G. Friend
Treasurer, Mr. A. B. Baird

The Tenth International Congress of Entomology will be held in Montreal from 17 to 25 August, 1956. The meetings will be held at McGill University and the University of Montreal.

SECTIONS

The Sections of the Congress have been arranged provisionally as follows:

1. Systematics
2. Morphology and Anatomy
3. Physiology
4. Behaviour
5. Ecology
6. Geographical Distribution
7. Genetics and Biometrics
8. Palæontology
9. Arachnida and other land Arthropods
10. Agricultural Entomology
11. Forest Entomology
12. Medical and Veterinary Entomology
13. Stored Products Entomology
14. Biological Control
15. Apiculture

These sections will, however, be interpreted so as to cover the whole range of entomological science. Symposia will be arranged in many of the sections. Further announcements will be made later.

EXCURSIONS

A visit to the Science Service Laboratories, Ottawa, and certain short excursions will take place during the Congress. Following the Congress, tours to a number of more distant laboratories and excursions for collecting will be possible.

A wide choice of accommodation in hotels, student residences, and guest houses will be available at prices ranging from $2 to $10 a night. Camping facilities are available at Macdonald College, about 25 miles from Montreal.

CONGRESS MEMBERSHIP

The Congress fee will be $15, with a reduction for accompanying members and student members. A charge will also be made for some of the excursions.

There will probably be limited dollar funds available for small grants-in-aid for living expenses for members who are not otherwise provided for. Such members are invited, when replying to this announcement, to ask for the form of application. Applications from members sponsored by governmental or commercial organizations, or from those residing in North America, cannot be entertained.

MEMBERSHIP

Those wishing to receive further information with a view to attending the Congress should notify the Secretary as soon as possible. They will then receive the application forms and a booklet giving more particulars.

These papers can be sent only to those who give the notification requested.

Those who would like to receive a personal invitation are requested to apply to the Secretary.

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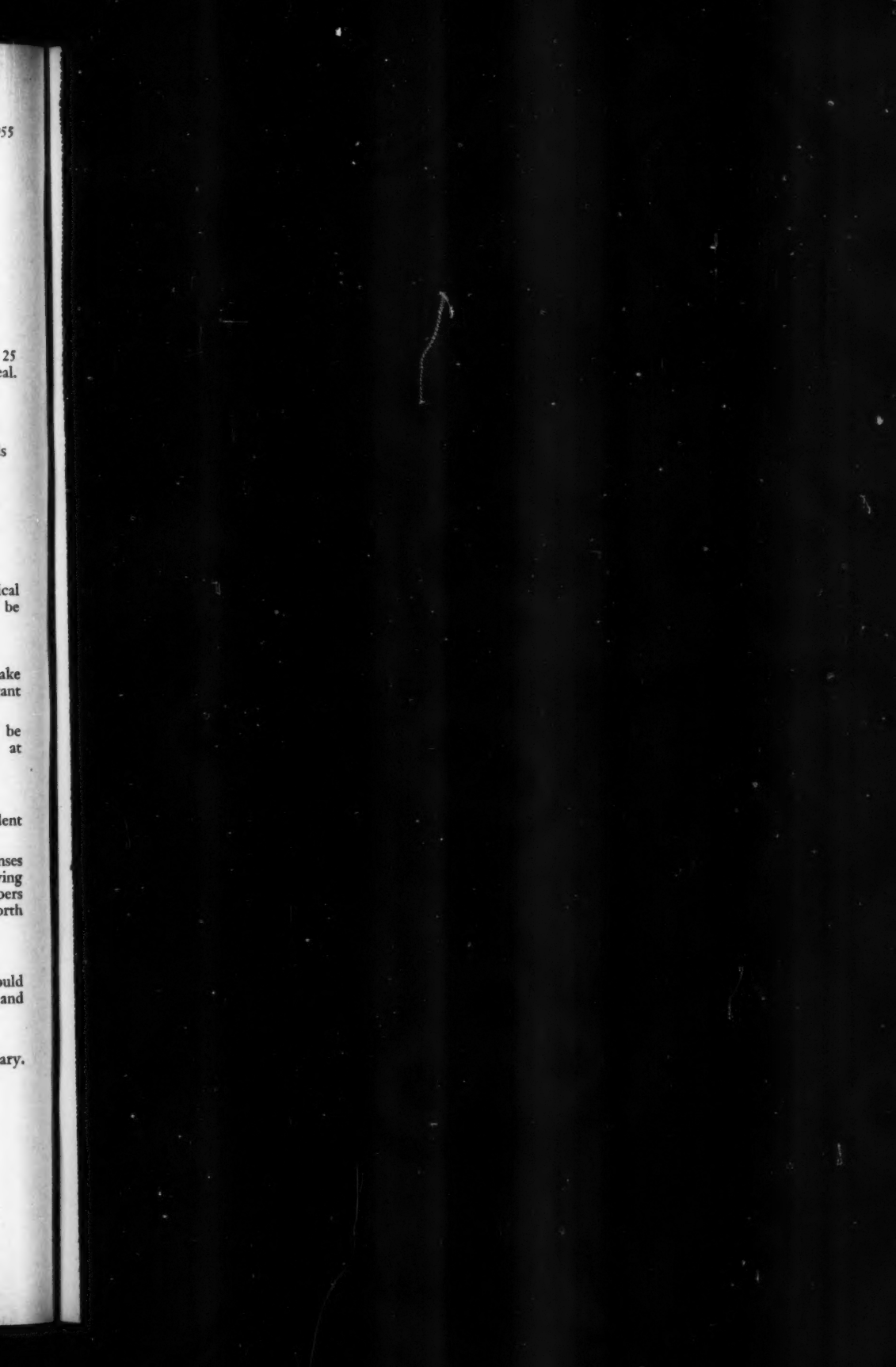
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